# CLOCK REPAIRING *and* ADJUSTING

*by* W. L. RANDELL

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PERCIVAL MARSHALL & Co. Ltd. LONDON

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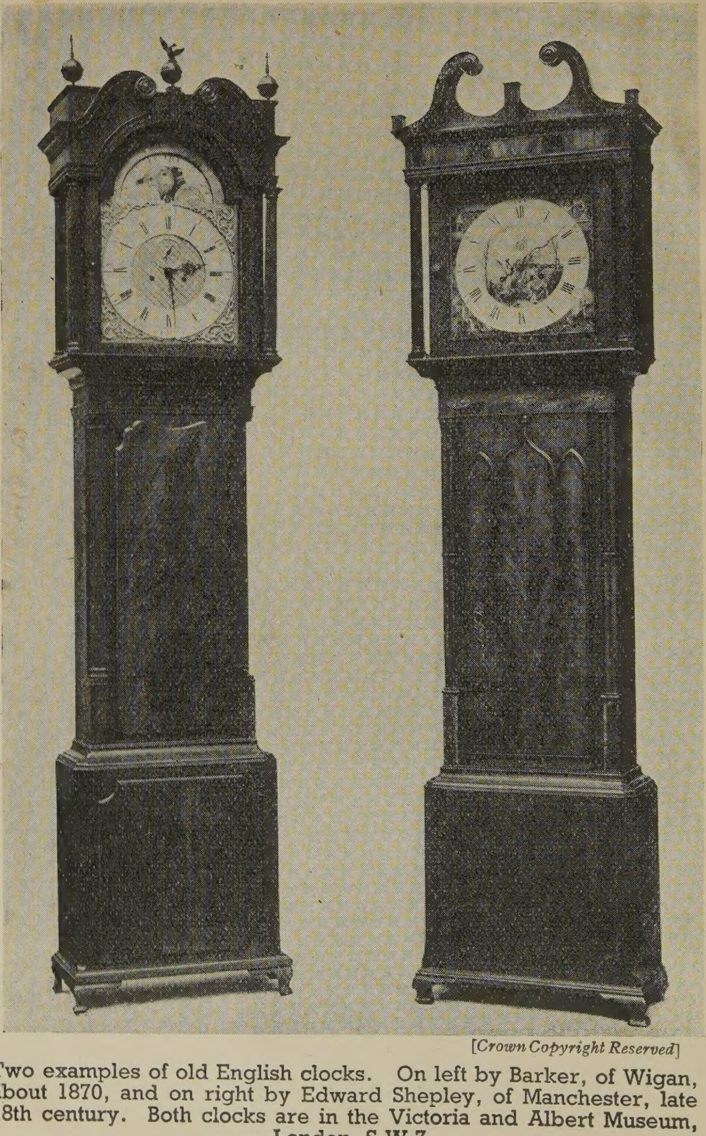

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Two examples of old English clocks. On left by Barker, of Wigan, about 1870, and on right by Edward Shepley, of Manchester, late 18th century. Both clocks are in the Victoria and Albert Museum, London, S.W.7.

# CLOCK
# REPAIRING AND ADJUSTING

By

W. L. RANDELL

*Author of "Watch Repairing and Adjusting"*

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# PREFACE

THIS handbook is written for those who have had no experience of clockwork, as an introduction to a branch of mechanics which becomes more attractive the more it is studied. It carries the student no farther than cleaning and elementary repairs to types of clocks familiar in most homes. The more abstruse matters of pivoting, wheel-cutting, calculating ratios of wheel-trains, re-making, and repairs which need a lathe, are not dealt with; for many of them, in fact, highly-skilled workmanship must be acquired by prolonged practice if they are to be carried out successfully.

There is ample scope, however, for the skill of the amateur in mechanical work even in the range of "domestic" clocks; and to the model engineer the striking mechanism, with its many pretty devices, will make a particularly strong appeal.

Every endeavour has been made to describe clearly the action of various parts, and to explain the reasons for stoppage commonly met with. It is not always easy, however, to place oneself mentally in the position of those who have never taken a clock to pieces; nor is it possible to mention every one of the scores of little faults which may cause trouble; therefore on any puzzling point not elucidated in the following pages the author will be very pleased to advise his readers.

W. L. R.

LONDON, 1923.

# PREFACE TO NEW AND REVISED EDITION

THE demand for some simple handbook such as the first edition of *Clock Repairing and Adjusting* was amply proved by the letters which have reached the author from time to time. Some came from distant parts of the world—New Zealand and South Africa, for instance; and many more, naturally, from nearer home. A number of the writers asked for advice, and to those who sent sketches special thanks are due; for often even the roughest drawing explains a difficulty better than a page of description. Others expressed appreciation—a tribute always valued. A few took the extreme step of sending a troublesome clock by post for attention; this is doubtless a compliment, but is not recommended.

The present edition has been enlarged by the inclusion of a little more historical matter of general interest to students of this fascinating hobby, and by various changes in or additions to the text which it is hoped will make certain points more clear.

W. L. R.

LONDON, 1946.

# CONTENTS

Page

*Preface* .. .. .. .. .. .. .. v

*Preface to New and Enlarged Edition* .. .. .. vi

A Little History .. .. .. ... .. 1

A Wonderful Machine .. .. .. .. .. 10

Tools and Accessories .. .. .. .. .. 11

General Remarks .. .. .. .. .. 16

Time-keeping Mechanism .. .. .. .. 18

The Escapement .. .. .. .. .. 21

The Pendulum .. .. .. .. .. .. 23

Striking Mechanism .. .. .. .. .. 25

Eight-Day "Grandfather" .. .. .. .. 28

Hands and Dials .. .. .. .. 36

The Clock Case .. .. .. .. .. .. 38

Thirty-Hour Chain Clock .. .. .. .. 40

The English Dial .. .. .. .. .. 48

German Dial: American Dial .. .. .. 54

Nickel Alarm .. .. .. .. .. .. 58

A Few Words on the Hairspring .. .. .. 63

Varieties of Alarm .. .. .. .. .. 64

Wooden Case Alarm .. .. .. .. .. 65

The Dutch Clock .. .. .. .. 67

French Striking Clocks .. .. .. .. 69

Carriage Clocks .. .. .. .. .. .. 79

Carriage Striking Clocks .. .. .. .. 82

Cylinder Alarm .. .. .. .. .. .. 84

Cuckoo and Trumpeter Clocks .. .. .. 86

Mainspring Repairs and Hints .. .. .. 87

Repairs to Wheels .. .. .. .. .. 90

Setting a Clock in Beat .. .. .. .. 92

Electric Clocks .. .. .. .. .. .. 93

*Glossary* .. .. .. .. .. .. .. 97

. . . Methinks it were a happy life
To be no better than a homely swain ;
To sit upon a hill, as I do now,
To carve out dials quaintly, point by point,
Thereby to see the minutes, how they run :
How many make the hour full complete,
How many hours bring about the day,
How many days will finish up the year. . . .
*King Henry VI*, Part III.

---

" Her heart beat regularly, like a serviceable clock."
GEORGE MEREDITH (*Diana of the Crossways*).

# CLOCK
## REPAIRING AND ADJUSTING

### A LITTLE HISTORY

THE measurement of time is undertaken, in the first place, by Nature ; and in one sense her measurements are rough, in another sense extremely accurate—for while she gives us nights and days of widely varying duration, and, except near the Equator, of a duration that alters with the seasons, the revolution of the earth on its axis and its magnificent annual motion round the sun, which cause day and night and the seasons, are among the most profoundly exact periods known to science. And upon the consequent apparent motions of sun and stars we can base with confidence the most precise and definite calculations and predictions.

When humanity concerned itself with the keeping of flocks and herds and the growing of vegetables ; when a man's riches were in his barn and byre and sheepfold ; when his clock was the sun, his pleasure the straight furrow, the ripening field, the trial of strength, the lamplit room ; when his enemies were nature's children, even as he was, pursuing their living, even as he did, honestly and without malice ; when from the earth he tilled and the flocks and herds he tended came the food and clothing he needed, and when spinning and weaving, milling and baking and brewing, were crafts of the home and hamlet ; then, dawn and noon and sunset served as reminders to begin, to intermit, and to cease work. Time, then, must have seemed the simplest of matters ; no task-master with a frown and a penalty, but as easy and uncontrollable and yet friendly as the weather, which, taking the year round, brought seedtime and harvest, its sunlit June to take the sting from sunless January, its sureness of fruit in due season.

With increasing trade and advancing civilisation came the need for more particular divisions of time. Science also demanded finer measurements, as science invariably does. To the farm-worker half an hour may not matter; to the factory-worker half a minute may be serious; to the astronomer, the engineer—and, possibly we might add the racing man—half a second may be important. So, for centuries past, man has divided his day into hours; his hours into minutes; his minutes into seconds; and by this compromise with the apparently changing but really changeless indications of nature's clock has arranged life's tasks and pleasures.

The time measurers of the ancients were sundials, hourglasses, and clepsydræ, or water clocks, which indicated the rate of time's passing by means of the escape of water from a vessel through an orifice. Until the year 293 B.C. the movements of the heavenly bodies appear to have been the only measure of time known to the Romans.

About 145 B.C. we hear of the clepsydra. In the Science Museum at South Kensington a model of one of its simplest forms can be seen, consisting merely of a large glass bowl filled with water and marked vertically with the hours. As the water escapes at a definite rate from a small hole near the base, the level surface, gradually descending, crosses the lines of the hours and indicates approximate time. There is also a "candle clock," the candle burning down at the rate of an inch an hour, rings an inch apart round the wax serving as indicators. King Alfred used this idea, the candle being protected from draughts by a lantern with horn windows.

Such methods proved fairly satisfactory in olden days, and there are legends of wonderfully complicated water clocks which recorded the hour by the dropping of little balls of metal upon a bell, and which possessed other qualifications, to be received with a certain amount of reserve. In A.D. 800, for instance, a clepsydra of quite incredible complexity is said to have been presented to the Emperor Charlemagne. Most of them had a scale over which moved a pointer actuated by a float, or a dial with a hand driven by a toothed upright rod and a small wheel.

Hour-glasses, consisting of two bulbs of glass united by a narrow perforated neck, were used in churches during the sixteenth and seventeenth centuries. The fine sand in the upper bulb falls into the lower one in a definite time ; and as the glass is mounted in a reversible frame the mere turning of this upside down resets the " clock." Discourses from the pulpit in those days had quantity as well as quality, and small boys must have watched the preacher's hour-glass anxiously. Pretty little sand-glasses of this type are still to be found, made to run out in about three minutes for the timing of boiled eggs.

In the twelfth century clocks with wheels are known to have been used in the monasteries, and from this date onward the expression " the clock has struck " is often found. A method of making clocks without the assistance of water was known about the year 1130, and these " dry " clocks were set up in churches as early as 1174. We hear of striking clocks in Italy in the thirteenth and fourteenth centuries, when tradition begins to merge into trustworthy records.

For the further history of clocks the reader may turn to any good encyclopædia ; but we may spare a little space here in which to honour the great old English makers whose names are to be found, even to-day, on clocks which are not likely to stop finally until long after we ourselves have come to rest—Graham, Harrison, Tompion, Quare, East, Wagstaffe, and others, to whom much of the perfection of the clockwork of to-day is due.

Let us look for a moment, first of all, at the Worshipful Company of Clock Makers of the City of London, which was incorporated in 1631 " for the better order, rule, and government " of all " using the Art or Mystery of Clock Making." One had to be a good workman, and to present a " masterpiece," to become a member of this august body ; and it had extensive powers. " Faulty and deceitful work or works " in the form of " Clocks, Watches, 'larums, Sun-dials, Boxes or Cases for the said Trade, Art, or Mystery of Clock Making " could be seized in the king's name " be they of what metal or of what nature, condition, or fashion soever," and " upon proof of insufficiency " before the Mayor or other officials could be broken up. The Master and Wardens could enter any house within ten miles of the city and " search for and survey the working and making, and seize, carry away, and deface all wares deceitfully wrought, every one hindering such search to forfeit the sum of £5." So you see, from this historic Royal Charter, how dignified is the profession, and with what a sense of responsibility we should enter upon our examination of even the humblest clock.

David Ramsay, clockmaker to James I, was the first Master of the Clockmaker's Company. Edward East, " the King's Clockmaker to Charles II," was Master in 1645 and 1652 ; he had a shop in Fleet Street, and was one of the ten persons named in the original Charter of members. He became treasurer to the Company, and gave £100 to it for the benefit of the poor ; it is recorded that the Master and Wardens conveyed to him in person their " hearty thanks for his charity." East died in 1701 at the age of 84 : a famous craftsman, high in the royal favour.

Thomas Tompion, " the father of English clock-making," also held the honourable post of Master of the Company, and is referred to in its records as "a great clockmaker." His ingenious brain brought into existence many inventions, and clocks by him are still going—one at Buckingham Palace, another in the Pump-Room at Bath, and a third at No. 30 Cornhill. This clock, according to Mr. Herbert Cescinsky, who gave an interesting account of it in the *Connoisseur*, strikes hours and half-hours, has a pendulum beating a second-and-a-quarter, and needs winding only once in forty days. It also has a subsidiary dial at the side of the case with an index hand for accurate regulation. Tompion made, in 1675, one of the first English watches with a balance-spring, under the direction of Hooke; adopting and often improving the ideas of others, he helped to give English watches and clocks the finest name in the world. He was born in 1638, and was buried in Westminster Abbey in 1713.

His contemporary, Robert Hooke, professor of geometry to the Royal Society, was not "in the profession." A mathematician and philosopher with remarkable mechanical genius, he made working models as a boy, among them a wooden clock. Later, when F.R.S., he measured the vibrations of a pendulum 200 feet long attached to the steeple of St Paul's. He invented the anchor escapement for clocks, also a machine for cutting the teeth of watch wheels, and was the first to apply a spiral spring—the "hairspring"—to the balance wheel of a watch. He is famous for his astronomical discoveries and his investigation of light; his reputation for quarrelsomeness may perhaps be put down to the fact that he studied all night and "took a short nap in the day."

George Graham, one of Tompion's pupils, born in Cumberland in 1673, invented the mercurial compensation pendulum in 1715, also the dead-beat escapement and the cylinder escapement—improvements which we shall mention in a later chapter. He was an expert in mechanics and "maths," a Fellow of the Royal Society, and Master of the Clockmakers' Company in 1722. Among his finest work must be included many splendid astronomical instruments for French and English observatories. For some years he was in business with Tompion, and was buried in his friend and former master's tomb in the Abbey.

Daniel Quare, believed to have been born in Somerset, another of the fine old City craftsmen, was a prominent member of the Society of Friends. Dr. G. C. Williamson, in his pleasant book *Behind my Library Door*, notes that Quare was "greatly respected and esteemed by people who moved in the highest social circle of the day." He made a repeating watch, also a clock showing the phases of the moon, for William III; this clock, altered by Vulliamy in 1826, is said to be still going at Hampton Court. Another is at the Royal Hospital, Greenwich. Quare invented a portable barometer, also the repeating action for striking clocks, and is believed to be the first to have used the concentric minute hand. Late in life he was appointed clockmaker to George I. He died in 1723, and others whom he taught carried on his fine tradition of good work.

The name of Benjamin Lewis Vulliamy brings us into Victorian times. His father, of Swiss origin, was a clockmaker in Pall Mall; the son enhanced the family repute by being elected five times Master of the Company and a Fellow of the Royal Astronomical Society. He erected clocks for many important buildings, and a very beautiful one for George III. He was born in 1780, and lived until 1854.

Thomas Wagstaffe, a famous maker of long-case clocks, flourished in the mid-eighteenth century; and the list might contain many more names. Of such men, Dr. Williamson says: "We have every reason in England to be proud of the exponents of this great craft, because even if we did learn the details of it first from Germany, and eventually from France, we have produced men who have been supreme in their own work, and who have been responsible for many of the chief inventions that have assisted in making the modern watch what it is."

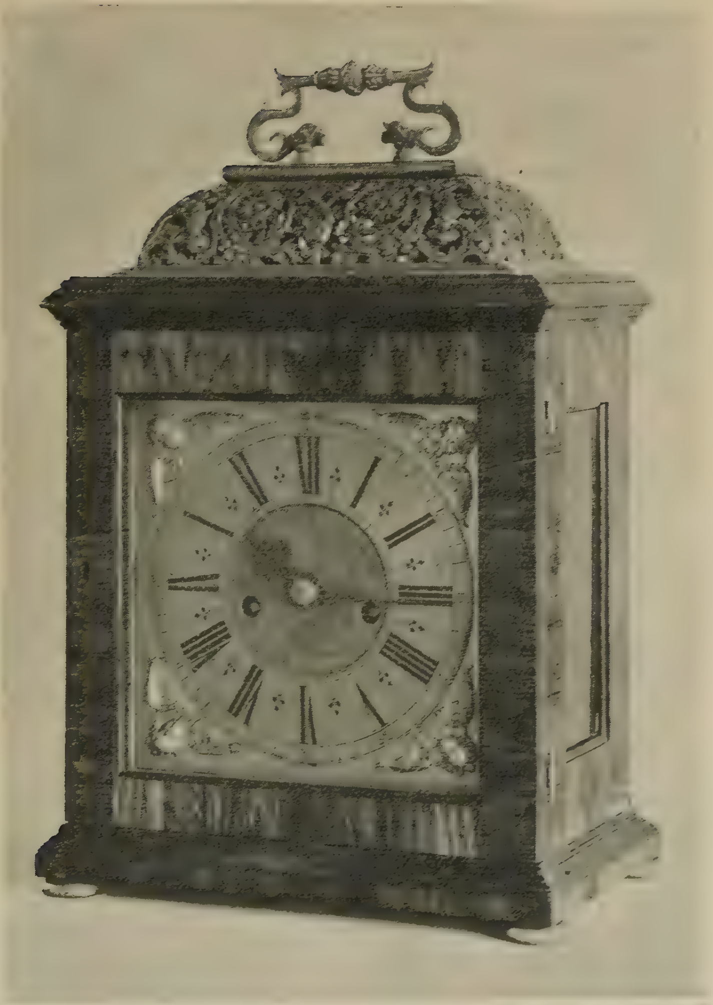
Nearer to our own day comes an exponent of the dignified craft whose name must not be omitted—Lord Grimthorpe. As Mr. Denison, a barrister, he designed in conjunction with the Astronomer Royal the Westminster Clock, "Big Ben," which was made by Dent in 1854. His three-legged gravity escapement is a masterpiece, and has been adopted in other turret clocks where great accuracy is required. He became President of the British Horological Institute in 1868, and later held the titles of Sir Edmund Beckett, and Baron Grimthorpe. He died in 1905, and stands worthily, in the annals of the craft, with the masters of earlier centuries.

In the Science department of the Museum at South Kensington, free for all to see in normal times, are specimens of the work of some of these master craftsmen, exhibited in a special room. Not merely exhibited, but actually going. For instance, there is an original eight-day clock made by Harrison. The wheels of this clock, with the exception of the scape wheel, are of wood; it is dated 1715.

Another very beautiful clock in action in this same room, is the one made by Vulliamy for George III. Instead of pivot-holes in the plates the bearings are large friction wheels, the pivots riding on the intersection of two rims. It must be seen to be appreciated. There are other masterpieces of the clockmaker's craft, including a double-dialled clock showing sidereal and mean time; and some considerably more than "life-size" models of various escapements in wood, which the student may inspect to his advantage. The whole collection, in fact, is a joy to the mechanically inclined visitor, and will probably give him a much higher opinion of the clock, as a machine perfectly adapted to certain ends, than he has hitherto held.

One more name should be added to our list: that of John Harrison. Although he is associated more closely with watches, some of his inventions have been applied with great success to the finer type of clock. Born in 1693, his father was a builder who carried on clock repairing as a side-line, and the boy certainly preferred this art to the handling of bricks and mortar. He practically taught himself to make clocks; at the age of 22 he built his eight-day clock just mentioned. In 1726 he devised his "gridiron" pendulum, the bob suspended by a series of parallel rods of steel and brass so arranged that the expansion of the steel rods was compensated for by the different expansion of the brass rods at changes of temperature. But his chief claim to fame is the definite step forward due to him in the science of exact time-keeping, and his achievement of designing and constructing a chronometer which brought him the reward of £20,000 offered by the Government to anyone who could discover a method of determining the longitude at sea within certain limits. Harrison built, after several trials, a chronometer which, during a voyage to the West Indies and back lasting over four months, showed an error of less than two minutes. Other tests gave evidence of even greater accuracy, and after he had persevered still further and met with many delays in the recognition of his work Parliament granted him the full amount. One of his chronometers, during a ten weeks' trial, varied only 4½ seconds from the correct time.

Harrison died in Red Lion Square, London, in 1776, and was buried at Hampstead. No textbook or history of horology can omit this great craftsman's name.



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English Bracket Clock, late 17th century. Victoria and Albert Museum, London, S.W.7.

## A WONDERFUL MACHINE

Now, wonderful to relate, science can measure time by thousandths of a second, and has given us a clock that "keeps time" (strange, contradictory expression!) to such amazing accuracy that the suggestion has been made as to the possibility of using it to check the uniformity of the earth's rotation: the period of that rotation, so they say, being subject to variation amounting "in extreme cases" to a change of one second per year. Thus good John Harrison, whose famous chronometer varied only 4½ seconds in ten weeks, is made to look very shamefaced. We have progressed—always assuming that "progress" is the right word—a very long way since the sundial and the water-clocks of ancient Egypt told men the hour.

When you come to consider it, a clock is quite a wonderful thing. Take it from the purely material point of view, as a machine, there are not many machines that will run without attention, without oiling, for a week, a month, a year, even for several years. Winding-up is, of course, merely a renewal of the motive power, necessary to any machine.

But look at it from a philosophical standpoint for a moment. A clock records or measures time; but what is time? Philosophers and scientists of all ages, from Aristotle to Einstein, have discussed this question, and have arrived at no satisfactory definition. "Time," says one dictionary "is the general relation in which all things perceptible stand to each other, in regard to their origin, continuance, and dissolution; it is a form necessary to enable the mind to unite successive existence." Time, space, and motion are inseparably connected in our apprehension of the world we live in; but there is one great difference between space and time which gives even to the cheapest little household clock something of dignity. We can go forward and backward in space; we can move across a room, a town, a continent, and come back again; but time is irreversible and irrevocable. We can never get back to five o'clock at ten minutes past; a fact which is of immense value to moralists. And it is this very obvious and well-known fact which imparts to a clock, as the recorder of time, an atmosphere of aloofness and unconcern and neutrality; it is so confoundedly impartial and single-minded—and so necessary. Which brings us to another point, the last in this brief study of the time-machine. It is not until a clock stops that we realise our dependence upon it and our confidence in it. Our clocks send us off to catch our train, send us out to lunch, send us to bed, make us keep our appointments, control our movements; we disregard them at our peril.

So, with the hope of enabling you to understand the ways of these universal monitors, and to set them right when they go wrong, these pages have been written. "What a dead thing is a clock!" wrote Charles Lamb, arguing in favour of the sundial. But we cannot have sundials in every room; nor can we have sunshine every day, unfortunately; and that ungracious complaint only shows that among the many things which Charles Lamb understood so delightfully clocks had no place.

## TOOLS AND ACCESSORIES

All repairs described in this book can be carried through without a lathe, though some of them might be done more quickly and perhaps more neatly with one. A small lathe that can be gripped in the bench-vice, driven by a hand-bow, and instantly moved out of the way, is certainly useful.

Several of the necessary tools are common things in the equipment of all mechanically inclined readers, but a little discretion is advisable. The ordinary overworked household pliers, for instance, with jaws that never close properly are all very well for "rough stuff" with rusty locks and a Saturday afternoon at the garage bench, but they won't do for clock work; nor will the coarse files and big screwdrivers be of much use. A pair of clock pliers and a pair of watch pliers (for the finer work on carriage clocks) must be obtained, also cutting nippers; files—flat, square, round, half-round, and triangular; a hand-vice; a light hammer; and a drillstock. Of the two or three small screwdrivers needed one must be a medium-sized watch screwdriver; this will have a loose top which rests on the palm of the hand or the ball of the finger, and it is turned by the finger and thumb. The list will be nearly completed by tweezers of steel, large and small, a pin-vice for filing up pins, drills, etc., and a small saw-frame with a dozen saws, like fretwork saws in appearance, but which will cut a piece of brass "like butter."

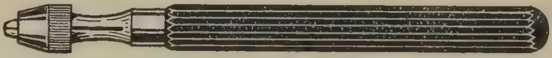

Fig. 1.—Pin-vice, for filing up pins, holding a broach, etc.

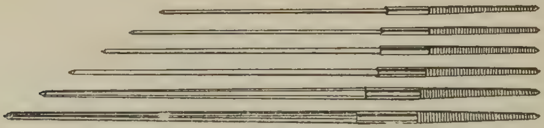

Fig. 2.—A set of clock-broaches, for enlarging holes.

Several broaches of graduated sizes, for opening holes, are essential; it will be best to get a set of these.

Punches and drills will be wanted, but nearly all drills, and many punches, are just as satisfactory when home-made from steel wire or scrap. You can put an edge on a drill

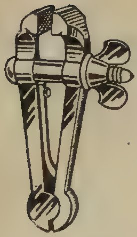

Fig. 3.—Hand-vice.

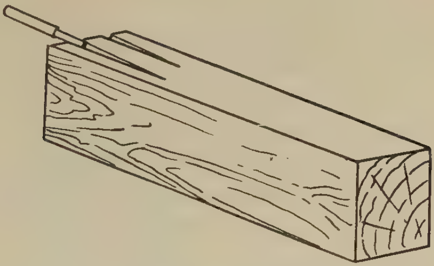

Fig. 4.—Filing-block of hard wood with grooves for filing up pins or burnishing a pivot, as indicated. To be gripped in bench-vice.

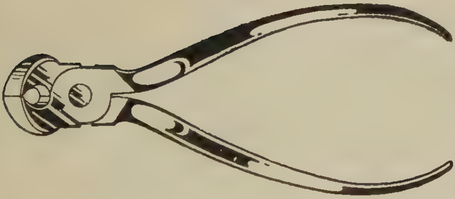

Fig. 5. Cutting nippers.

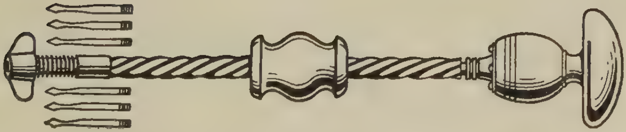

Fig. 6.—Archimedean drillstock.

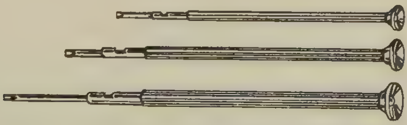

Fig. 7.—Watch screwdrivers, for clocks with watch escapements.

made in five minutes that will turn out beautiful curly shavings of brass like a miniature drilling-machine.

A word or two on making such a drill may not be out of place. Take a scrap of steel wire rather thinner than the size of drill desired ; soften it to dull red heat. Flatten the end with the hammer on the anvil of the vice, and if necessary file it a bit, till it is like a ragged screwdriver blade. Then file it up as shown in the illustration, finishing off each of the two cutting edges with a fine file ; heat it to dull red again, and quench it *suddenly* in a cake of yellow soap or in oil (not clock oil). It should now be glass-hard. Bring up the surface with emery cloth, then hold it cautiously in the flame of a spirit-lamp or a lowered gas-flame, warming the thicker end until you see the cutting blade and shank have become a pale straw colour. Touch the edges on an

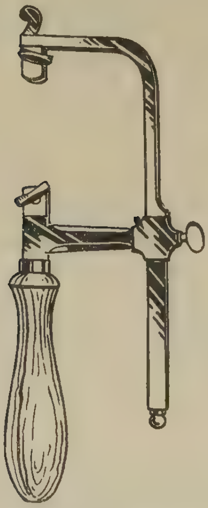
Fig. 8.—Adjustable saw-frame.

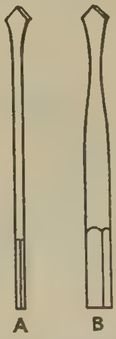

Fig. 9.—Drills.
A, for ordinary work.
B, for heavy work.

oilstone a few times, and you have a drill that will cut at a surprising speed when in the stock. The upper part of the shank can be squared of course, to fit the chuck of your driving tool, or to take a "pulley" may be tapered as required. Three or four drills of progressive sizes will be enough for all ordinary clock repairs. For very fine work excellent tiny drills can be made from needles.

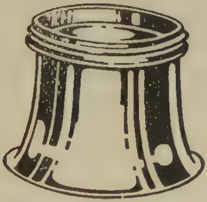

Fig. 10.—Eyeglass, for clocks with watch escapements.

For cleaning purposes some long, narrow brushes, both stiff and soft bristled, are used ; a soft duster, a bundle of pegwood for "pegging out" the pivot holes to clean them thoroughly. Any soft stick that can be twirled between finger and thumb will answer the purpose ; even waste matches will do. Sharpen the stick or match to a tapering point each time, cutting away the soiled parts.

An eyeglass is absolutely necessary for the finer work such as the escapement of carriage clocks.

Only the specially prepared clock oil or watch oil should be used ; it is quite wrong to "make do" with other lubricating oils, which in a few months will thicken and by mere gumminess cause trouble. The proper oils can be bought in the Clerkenwell material and tool shops, and one bottle of each will last for years.

## GENERAL REMARKS

For the purposes of the amateur, domestic clocks may be ranked in two groups : those with pendulums, and those without. This is a very broad division, with many subdivisions which need not be enumerated here.

Obviously, pendulum clocks include the stately eight-day grandfather, the pride of generations, beating out dignified seconds, trustworthy to a minute or so a month, and the active little paper-faced nondescript, waggling its way through time, mislaying several minutes to-day and overtaking them to-morrow. And clocks without pendulums range from the exquisitely finished carriage timepiece with a watch escapement to the nickel alarm, with as many varieties as sweet peas ; these cheap drum clocks, by the way, being extraordinarily serviceable. Some of them you can almost play football with, and they will still come up smiling. The bother with a cheap clock, however, is that when it *does* stop, it stops thoroughly, and may give even a clever watchmaker no end of trouble—simply because it isn't worth the expense of new holes and a new wheel or two, and he has to try to make it go by sheer rule-of-thumb adjustments. That is, if he consents to have anything to do with it at all. With a finely-finished, expensive clock the cause of stopping is usually clear ; once that is discovered, the remedy follows as a matter of course.

I have preferred this method of grouping to the even more obvious one of striking and non-striking clocks, because the striking part of a clock is simply a matter of additional mechanism and not an essential difference in construction. So, with this preamble, we will get to business.

The mechanism of modern time measurers often appears, even to the man who is accustomed to machinery, too complicated for attack. In the first place, it is firmly pinned or screwed into a framework or case, and if in a moment of determination he manages to extract the " works," the idea of taking them to pieces before the admiring but critical gaze of the family gives him stage-fright. If, further, he takes the plunge, and the clock lies before him in astonishing disarray, the picture of himself humbly presenting the collection of wheels and levers, done up in a newspaper, to the nearest watchmaker, will sometimes prove unnerving. And if he arrives at the splendid point where he has managed to assemble the parts, it is possible that the clock refuses to go, and more likely still, if it has a striking train, that the striking is wrong.

Yet, once the principles of clock mechanism are grasped, most of the difficulties vanish, and the model engineering enthusiast with a general knowledge of wheel work and levers should find no great trouble in cleaning and repairing his household timekeepers.

Remember, when a clock digs itself in and refuses to see reason, that somewhere or other exists a *purely mechanical* fault. There is no imperfect electrical contact to look for, no point of weak insulation, nothing mysterious. Somewhere, one or more of a dozen things can be giving trouble —rough pivots, worn holes, a tight hour-wheel, a bent tooth, a wheel with too much or too little end-shake or " play," cut pallet-faces, a lifting piece not free. Any one of these can cause a clock either to act sluggishly or erratically or stop.

There are two cautionary words to be emphasised before you begin. The first is, Go slow. Never take a clock to pieces before you have had a good look at it. For this there are two reasons : one is that the fault that is stopping the clock is often easily spotted once the works are visible, but not so easily when they are taken down. The other reason is that if you are new to clockwork, you will find the putting together again a worrying job unless you have carefully examined the movement before beginning—especially with a striking clock.

The second caution may be thought superfluous. It is: Never use force. The delicate hand and temper succeed with clock and watch work; it is so easy to get annoyed when a pivot won't enter its hole or a wheel locks itself sideways between the plates with a perfectly abominable persistence that can only be ascribed to cussedness; but a little undue pressure in a moment of irritation means a bent pivot, and a bent pivot often means a snapped pivot—which means a trip to the watchmaker and some shillings out of your pocket, unless you are very clever indeed.

So, before you start, handle your clock, as a whole, tenderly; examine it well; if it is a striking movement, try the striking round many times, moving the hands very slowly and watching what happens until you understand the sequence of events. And then, when in difficulties, perhaps one of the following chapters will help. That this may be so, the author sincerely wishes.

## TIME-KEEPING MECHANISM

A clock, to define in simple fashion what may be at times an elaborate thing, consists of a train of wheels between two plates or in some convenient frame, impelled by a weight or spring suitably applied; and an escapement, the final wheel of the train being a part of this, the object of which is to keep in motion a pendulum or balance wheel. The object of the pendulum or balance wheel is to regulate the speed of the train of wheels.

This definition is really that of a timepiece—the word signifying in the trade a clock without striking or alarm mechanism. The ordinary timepiece, then, is simply an apparatus for keeping a pendulum or balance wheel in motion and recording the number of its oscillations. In certain types of electrically driven clocks the pendulum impels the train of wheels ; in all ordinary clocks the train, by means of the escapement, " drives " the pendulum.

The number of wheels, and the proportions of the gearing, may vary ; but one wheel, the arbor of which carries the minute hand, must obviously revolve once in an hour. The minute hand as a general rule (to which there are exceptions), is not fixed firmly to this arbor, but fits on the square of the " cannon pinion," which is so attached to the arbor, either by the intervention of a spring or by a friction-grip, that it revolves with it ; so that the hand can be turned round without affecting the train. In some clocks the same result is attained by making the arbor itself a tight fit in the boss of the centre wheel ; in this case the cannon pinion is knocked firmly on the centre arbor close to the front plate and does its usual work of driving the motion wheel, while the minute hand fits on the arbor itself. Still another arrangement, found in some carriage clocks and in many watches, is a hollow arbor for the centre wheel ; into this fits the steel piece carrying the minute hand, the other end of it being square to take a watchkey.

The object of the motion wheel which revolves on a pin outside the front plate and gears into the cannon pinion, is to transform the once-an-hour revolution of the centre wheel into the once-in-twelve-hours revolution of the hour wheel, which carries the hour hand. Suppose the cannon pinion and motion wheel each have 36 teeth, and the pinion of the motion wheel has 6 leaves gearing with the hour wheel of 72 teeth, the requisite speeds of revolution will result. Other numbers, of course, are found, but as long as the correct relationship between the rate of minute wheel and hour wheel is preserved the object of the "motion work," as this set of wheels is termed, is attained. The hour wheel is the largest, and fits loosely over the cannon pinion. It should never fit tightly. If you think for a moment, you can see how a tight hour wheel takes the power off and stops the clock.

The wheels of the motion work, in a striking clock, carry the pins which raise the lifting-pieces and control the striking.

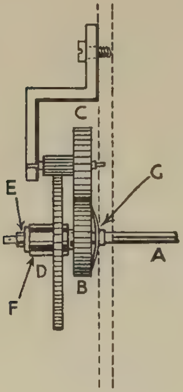

**Fig. 12.—Showing principle of motion-work.**

A. Arbor of centre wheel. B. Cannon pinion or minute-wheel. C. Motion-wheel. D. Hour-wheel. E. Socket of cannon pinion (part of B). F. Socket or pipe of hour-wheel. G. Flat brass spring between plate and under surface of B. Type of motion-work found in 8-day English clocks.

The proportions of various trains, and the calculations necessary to design them, do not come within the province of this book ; but we may take just one example : a clock with a pendulum beating seconds. The main wheel—the first, largest, and slowest wheel of the train—may have 96 teeth, and engage a centre-wheel pinion of 8 leaves. The centre wheel, with 64 teeth, engages a pinion of 8 on the third wheel. The third wheel, with 60 teeth, engages a pinion of 8 on the scape wheel. The scape wheel, under the control of the seconds pendulum, will move on half a tooth's space at each oscillation, so with 30 teeth it will revolve once a minute, and its arbor, prolonged to the dial, may carry a seconds hand.

There are variations in the numbers of teeth and pinions, also in the actual number of wheels in the train—since some clocks are meant to go for one day, others for 8, 15 or 21 days, with a single winding; the above example, however, may serve for our present purpose.

## THE ESCAPEMENT

Although it can hardly be said that any one part of a clock is more important than another, since mainspring or weight, wheels, escapement, and pendulum or balance all form a team working together for the common good, and if one member is taken ill the others get thoroughly upset, we can safely say that the most interesting part is the escapement. The term includes the scape wheel, pallets and crutch; it is also the part which interests young people who, like Toddie, "want to see the wheels go round." The scape wheel has teeth of a special shape which engage, not with any other wheel or pinion, but with the pallets—the rocking lever with two acting surfaces which alternately release and check a tooth of the wheel as they swing up and down in their small arc. As each pallet face slips over its tooth, the advancing wheel gives it a slight impulse

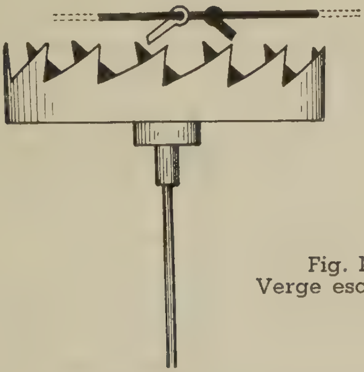

Fig. 13.—
Verge escapement.

which is conveyed to the pendulum by the crutch, thus maintaining the oscillations.

The earliest form of escapement was the "verge" or "crown wheel" type. In this the axis of the pallets is at right angles to the scape wheel, which is of the crown type and set vertically. From the drawing (Fig. 13) you will see that the pallets, which form part of the verge, are apart from each other, the distance between them being equal to the diameter of the wheel. The action of this escapement is noisy, and no great accuracy of timekeeping can be expected from it; the pendulum, which is light and attached to the verge, swings out fussily and seems to be doing quite a lot of hard work. Since the verge escapement is obsolete little need be said about it. You might meet with it if you come across a genuine antique bracket clock; and should you possess one of the old family treasures in the shape of an ancient "turnip" watch it is almost certain to have this type of escapement. The most usual trouble is cutting of the pallet faces where the teeth drop on them with a bang; also general wear of pivots and holes. Later pages of this book will set you in the way of curing such faults; but a clock of this sort is not often seen now.

Many forms of escapement have been devised, some of them highly ingenious and beautiful, but the simple anchor type invented by Hooke in 1675 is the one most frequently met with in domestic clocks.

This is a "recoil" escapement; as you can easily see, the inward movement of the pendulum after each tooth has dropped gives a slight backward motion to the wheel. Obviously, this is a defect, wastage of power; yet in spite of such a glaring fault the recoil escapement gives excellent results when well made, and fairly good results even when badly made.

In the "dead-beat" escapement the recoil is absent. After a tooth has passed the pallet, the wheel remains perfectly still until the next tooth drops. You will find escapements of this type in the better sort of clock—the heavy marble clocks with visible escapements are nearly always dead-beat; and often the pallets consist of suitably cut ruby pins. Good timekeeping is certain with this escapement, other things being equal; good, that is, for all ordinary purposes. When you want the time to a second or two a week other arrangements are necessary which are outside the domestic clock circle.

The most beautiful escapements of all—I must just mention them, though no household clock ever has them—are the "detached," where gravity supplies the impulse to the pendulum and any variations in the driving-force of the train make no difference to the oscillations. Many turret clocks have gravity escapements on this principle, and any of my readers who have not seen one should make friends with the vicar, or with the watchmaker who has charge of the church clock, which will possibly have one. E. B. Denison, afterwards Lord Grimthorpe, invented the famous double three-legged gravity escapement in 1851 for the clock which we all know as "Big Ben"—though that is really the name of the bell. Not only the escapement, but the striking and chime work of turret clocks is well worth examination.

## THE PENDULUM

Lord Grimthorpe said of the pendulum: "The credit of the invention was claimed by Huyghens, by Galileo's son, and by the celebrated Dr. Hooke." Who are we, to presume to decide? At any rate history tells us that Galileo *père* by watching the swings of a large hanging lamp in the cathedral at Pisa and timing them by the beating of his pulse, discovered that the vibrations were performed in the same time whether long or short. In other words, that a pendulum—a weight hung on a string, for instance—oscillates in the same time whatever the extent of its arc of vibration. This is not *absolutely* true ; but where the swing is not more than two or three inches on each side of the central line it is so nearly correct as to make no appreciable difference. After Galileo had made a little portable machine with a small weight on a string of variable length, for use by doctors in timing a patient's pulse, he contrived a timepiece with an escapement controlled by a pendulum ; it had many faults, and never came into common use, but it has its place in history, and it is recorded that his son elaborated the idea.

The manner in which a pendulum is suspended is important. It might be thought that some device such as a knife-edge bearing would give a better result than the almost universal suspension spring ; but, after much experience, the flat spring, provided that it is firmly and squarely gripped and of the right strength, is found to act perfectly. Friction between moving surfaces is eliminated—that is the great point. There is the resistance of the air to reckon with, but this needs attention only in the finest astronomical clocks.

Compensation for the variations in length due to temperature is necessary in some of the higher-class clocks, but is not really needed for house clocks, where extreme accuracy is not desired. A steel pendulum rod is better than a brass one, its expansion (*i.e.* lengthening) due to heat being about half that of brass. Some clocks, such as regulators, have a " gridiron " pendulum of two metals, the variation in their expansion being used as a mode of maintaining precise length in summer and winter temperatures ; and the mercurial pendulum gives very good results. the mercury in the jar forming the bob rising as the rod lengthens. " Invar," a steel and nickel alloy, which hardly expands at all in heat, is one of the best materials possible for a pendulum rod; but a plain wooden rod, varnished, has very little temperature-error.

## STRIKING MECHANISM

There are two devices in general use to cause a clock to announce by sound the correct hour; these are known as the " count wheel " and " rack."

The count wheel is simply a circular locking-plate with its rim notched at graduated intervals, corresponding to the twelve hours; on the rim, when the striking train is released, rides the edge of a lifting-piece. While this rides, the striking goes on; when a notch comes round and allows it to drop, it locks the train immediately after the last stroke of the hammer. If the striking train is wrongly adjusted, it locks at the wrong moment—perhaps when the hammer is half lifted for another stroke; this is one quite common cause of incorrect striking. The count wheel is generally pinned on, outside the back plate, the lifting-piece or a part of it projecting through either a hole or a slot; by opening the back of the case its action can often be seen. The wheel itself is driven slowly round by a suitable pinion or arbor (figs. 20 and 23).

The " rack " device is rather prettier, but is on the front plate, so is not visible until the dial is removed. It was invented by the Rev. Edward Barlow in 1676. On the hour wheel (remember that " hour " wheel and " minute " wheel, though terms universally employed, are in one sense incorrect—the hour wheel carries the hour hand, and therefore revolves once in twelve hours; the minute wheel carries the minute hand, and revolves once in an hour) is fixed the equivalent of the count wheel—the " snail," a spiral-shaped plate of brass either stepped from 1 to 12 or proportionately curved. Against this falls the tail of a toothed rack, the position of the snail determining the length of the drop, and therefore the number of teeth to be picked up, one by one, by the revolving "gathering pallet" before the striking train is locked by the tail of the gathering pallet coming against the stop-pin on the rack-head, or by a pin in the pallet wheel banking against a lifting-piece (see figs. 14 and 15).

One difference between these two methods of controlling the striking is that if you set the striking train of a count-wheel clock in motion by raising the lifting-piece from its notch, it will strike the *next* hour; but if you set free the striking train of a rack clock it will strike the last or current hour unless the next hour is fairly near. Therefore a "rack" clock can be used as a repeater, except when "on the warn" at the hour; and with an eight-day grandfather (almost always a rack movement) one sometimes finds an arrangement which enables a string to be attached to an arm bearing on the warning lifting piece (see fig. 14); this, when pulled, causes the clock to strike.

Again, if you turn the hands of a count-wheel clock round rapidly, not allowing it to strike, it will strike wrongly when you cease to turn them, since the count wheel has not moved to correspond with the motion of the hands; whereas if you do the same to a rack clock the snail moves with the hour wheel and the clock strikes the hour shown by the hands. There is no need, therefore, when a rack clock has accidentally stopped or been allowed to run down, to "strike it round," waiting for each hour. The only thing necessary is to let it strike twelve, so that the rack-tail may come up clear of the advancing edge of the snail. If this is not done, there is a risk, in some clocks, of a bent rack-tail, which may give trouble. With a count-wheel clock you must let each hour strike when setting it to the right time.

The rack drops when the clock "warns"; as the hours progress from one o'clock it has of course a steeper drop, and the knock of the rack-tail on the snail causes a quite recognisable and characteristic sound.

A single stroke at the half-hour is obtained in a count-wheel clock by increasing the length of the spaces in the count wheel, so that the train can run for one revolution of the wheel which carries the stop-pin ; a pin in the motion wheel lifts the warning-piece in the usual way, but is set exactly opposite the one which controls the hour-strike. In a rack clock this second pin is slightly nearer the centre of the motion wheel, so that the lift is not quite so high, and the first tooth of the rack is shortened. The rack therefore only drops one tooth, its tail not touching the snail at all.

Obviously, in a count-wheel clock designed to strike one at the half-hour, the space between the 12 and the 2 on the count wheel will be a long one, there being three consecutive single strokes, for which the lifting-piece is not required to ride free from the stop-pin or cam that locks the train.

In the better-class of rack-striking mechanisms the deep edge of the snail is bevelled and polished. Should the striking train stop acting for any reason while the going train continues, the edge of the snail at twelve o'clock, instead of butting against the rack-tail, gently pushes it aside without doing any damage and without stopping the clock. The rack-tail is slightly springy, and though there will be a little extra friction to overcome as its stud slides across the surface of the snail (being displaced), it will not be sufficient to take the power off the going train.

It is clear that too much endshake to the hour wheel may cause wrong striking, owing to the rack-tail touching its surface, or the tail resting on the edge of the snail instead of the pin or stud doing so. This fault should be cured by putting a thicker collet in front of the minute hand. Put on the hands without the dial and the adjustment of the play of the hour wheel will be easy. It is very important, however, not to go to the other extreme, and make the hour wheel bind against the minute-hand socket. A tight hour wheel will stop the clock, and is not an infrequent fault.

F. J. Britten, in his *Watch and Clockmaker's Handbook*, describes a second arrangement for causing a rack clock to strike the half-hours. In this, one arm of a bell-crank lever rides on the edge of a cam fixed to the motion wheel. Just before the half-hour this cam allows the lever to drop slightly, and its other arm, falling a little beyond a pin in the rack, prevents the rack from descending more than one tooth. After the stroke, the advance of the cam raises the lever again, and the rack is free to fall at the hour. This mode, as far as I know, is not often met with ; but the idea is excellent.

## EIGHT-DAY " GRANDFATHER "

I could wish nothing better for the beginner in clock repairing than that he should pick up for a shilling or two an old eight-day " grandfather " movement, green with verdigris, from a second-hand furniture shop, a marine store dealer, or a stall in a side street. If it has a dial and hands the seller will want more money for it ; but the absence of these doesn't much matter as long as the motion work and striking mechanism are there. It is the " works " you want ; you can rig up a pair of temporary hands if necessary, in the later stages. I have before now found one of these movements in such a pathetic condition that it was hardly recognisable as a clock, and have spent many pleasant hours at its toilet, filing, scraping, repairing, adjusting, polishing, until it was mounted on the test-bracket and going with all the energy of renewed youth. For the remarkable thing about these clocks is that they seem to go on imperturbably from generation to generation. It has been said that " old British clocks, like old churches, never wear out." Quite possibly the already respectably mature timekeeper mentioned by Goldsmith in "The Deserted Village":

> "The whitewashed wall, the nicely sanded floor,
> The varnished clock that clicked behind the door,"

is still steadily telling the hour in some country corner, thanks to the attention of craftsmen who loved their work.

Your house clock, however, will not be in such a sad condition as the discarded movements of which I wrote; it will probably have stopped through thickening of the oil and an escapement choked with dust. Slide off the top of the case; lift the pendulum slightly upward with your right hand, and with your left hand guide the pendulum-spring out of its notch and down clear of the crutch. Take off both weights, and then lift down the movement.

Examine it carefully. The striking will be of the rack type. Unpin hands and take off dial and bell; then, before removing any of the dial work, put on the minute hand and try the striking round, pushing the main wheel. Watch how the dial work is affected, how the "warning" is caused, and how the stepped spiral snail on the hour wheel controls the drop of the rack at each hour.

If you are new to clock work, spend some time over this; it will not be wasted. A rough pencil sketch will help, for not all these clocks are exactly alike; the positions of various lifting-pieces may vary.

The falling of the rack sets the striking train free, but it is pulled up almost directly by the warning-pin on the wheel next to the fly coming against the arm of the lifting-piece *c*; until this lifting-piece drops at the hour the striking is held up (figs. 14 and 15).

When you have grasped the essential points of this mechanism, unpin the various items of the dial work, take out the pallets, unscrew the nuts that hold the pillars down to the rising-board, and remove the pillar-pins.

The plates will now be free, and you can remove the top one. Take out the wheels of each train, endeavouring to memorise their positions, and keep the two trains separate;

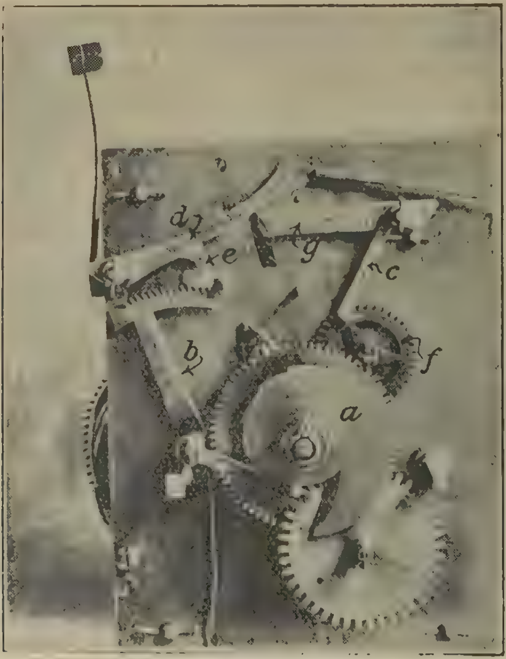

Fig. 14.—Front plate of 8-day Grandfather Clock ; dial removed.

*a.* Snail on hour-wheel. *b.* Rack. *c.* Warning lifting-piece, upper arm. (*g*) Passing through slot in plate. *d.* Rack detent. *e.* Position of gathering-pallet. *f.* Motion-wheel.
Position shown : Clock is "on the warn." Rack has dropped, its tail resting on twelfth step of snail. In another minute or two lifting-piece *c* will drop from the pin on *f*, release the pin on the warning-wheel, and free the striking train.

it is as well to have a few old cardboard boxes or cigar-boxes handy when taking down a large clock of any kind.

At this stage you can blow off any accumulations of dust on the plates or rising-board. The condition of these movements after years of unattended running varies surprisingly; some will be black with dirt and fluff, others will be comparatively clean, suffering only from thickened oil or dryness. It is largely a matter of how well or how badly the head of the case fits.

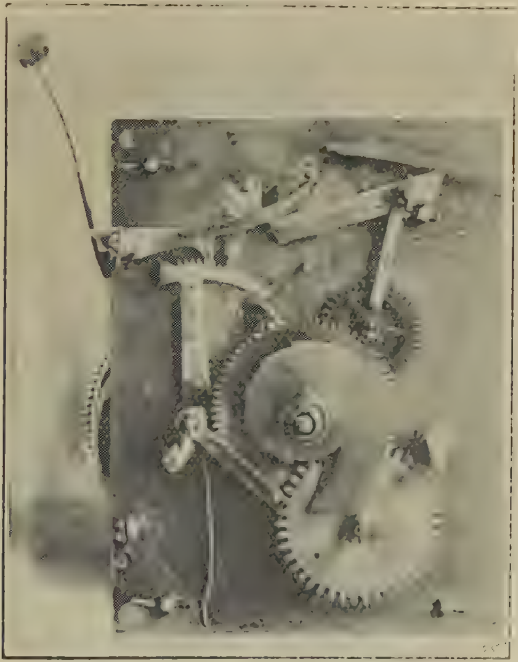

Fig. 15.—Refer to previous figure.

Lifting-piece *c* has fallen; striking is in progress; rack is partly gathered up. By the next hour the snail will have advanced so that the rack-tail can only drop on its highest part; and the clock will strike one.

With a movement in a bad state there is nothing for it but a rough brush over each part (using a stiff brush), a removal of the worst of the solidified oil and rust on pinions and arbors, and a bath of petrol (away from any flame). Brush the plates, hands, wheels, etc., with this volatile fluid. The various parts dry off quickly after their dip, and the next process is to use emery cloth on the parts that need it, and to do as much polishing as you feel inclined to do, with whiting or rottenstone, on a pad of cloth, or any other suitable method. Every clock repairer has his own preferences in the matter of cleaning.

Polishing, except of the bearing surfaces, will not improve the going of the clock, but there is something pleasing, suggestive of having made a good job of it, in wheels that gleam and plates that reflect your face. It's a matter of elbow-grease and temperament.

It is sufficient to brush out the teeth of most of the wheels thoroughly ; but special care should be given to the teeth of the scape wheel. Without filing them (which might impair the action of the escapement) see that they are clean and free from all roughness ; also that the pallets and crutch are smooth on all rubbing surfaces.

All pivots should be bright. To get them into good condition, grip in the vice a piece of hard wood with a notch in it ; rest the pivot in the notch, holding the wheel in your left hand, and with your right hand run a flat burnisher to and fro over the pivot, at the same time twirling the wheel backward and forward against the direction of the burnisher. With a little practice you can keep this action up indefinitely, the result being a nice bright pivot (fig. 4).

If the pivot is badly worn or tapered, or rusty, you may correct this by using a fine flat file with a safe edge in the same way ; the safe edge being against the shoulder, which must not be filed. Be sure to burnish the pivot afterwards. If the diameter of the pivot is reduced much you will have to rebush its hole—or in trade language " put a new hole in."

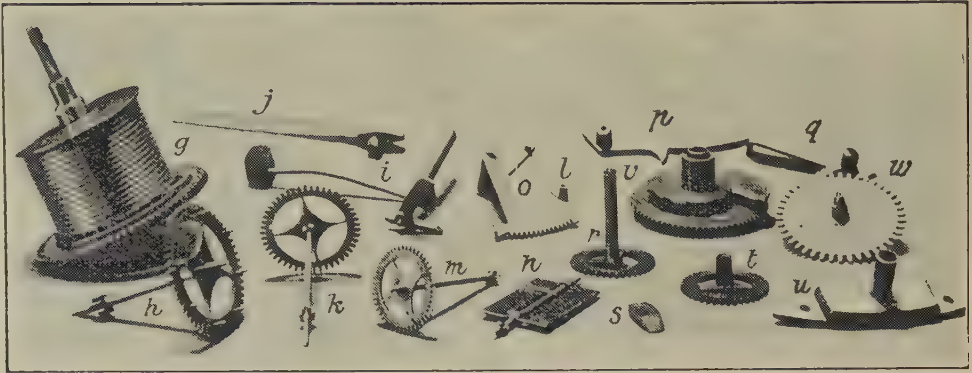

Fig. 16.—Striking mechanism of English 8-day clock.

*g*. Main wheel. *h*. Pin or hammer wheel. *i*, *j*. Hammer and its spring. *k* Gathering-pallet wheel. *l*. Gathering-pallet. *m*. Warning wheel. *n*. Fly. *o*, *p*. Rack and its detent. *q*. Warning lifting-piece (partly hidden by *w*). *r*, *s*. Cannon pinion and its spring. *t*. Motion-wheel. *u*. Bridge of cannon pinion on which rides (*v*) the hour-wheel *w*. Day of the month wheel, often a useless addition.

So much for cleaning, and these instructions may be modified, of course, if you are dealing with a movement that has been periodically cleaned and kept in good repair. But the majority of these clocks, though they will go when badly worn, are all the better for some simple repairs, and the most frequent fault is that the holes of the scape wheel and pallet pivots are oval, allowing far too much play, and thus making the depth wrong. To correct this by putting in new holes is not difficult.

" Clock tubing " for this purpose is obtained from the material dealers in short lengths and assorted sizes. Select a piece, the hole in which either fits the pivot tightly or is *just* too small. Broach open the old pivot hole very carefully with an even, steady twist, until the tubing will just enter the plate, but will not pass through. Saw off the end to a fraction over the thickness of the plate, and tap it home with the hammer ; a few sharp blows will then rivet it firmly in, and with file and emery and a final of rottenstone, or your favourite polish, you can finish it off so neatly that there is scarcely any trace of the repair. Countersink the hole on the outer side with a few turns of a large drill, or a graver, and then see that the pivot is a snug but perfectly free fit. To make certain of this, put that wheel only between the plates, pin them up tightly, and spin it. If you have any doubts, the slightest touch of a broach in the new hole should ensure the correct degree of freedom.

If the steel faces of the pallets are deeply cut into grooves by years of wear, it is possible to refile them and readjust the escapement ; but for the amateur the best plan is to put in a new hole of a greater length than the width of the plate, thus compelling the scape-wheel teeth to act on the unworn portion of the pallet faces. This, of course, means that the opposite hole must be sunk a trifle, or else that the shoulder of the pallet pivot must be filed back a little, to allow the necessary endshake. Be careful, when filing back the shoulder of any pivot, not to take off too much. When this repair is finished, put the escapement alone between the plates, pin them up, and make sure that the endshake of scape wheel and pallets is such that the scape-wheel teeth cannot act on the cut portion of the pallet faces.

If this repair has been done before, you may find that it is not possible to shift the pallets or the wheel so as to secure a fresh acting surface. In this case you can reface the pallets with two small pieces of watch mainspring and make them almost as good as new. This is one of the jobs where soft-soldering is permissible. Soften the mainspring to a blue tint for an inch or two, and shear off two pieces about the size of the worn surfaces of the pallets. Clean them bright, and tin them on one side in the flame of a spirit-lamp ; do the same with the pallets, tinning of course only the grooved faces. Then warm the pallets in the flame, slowly, until the film of solder runs, and press each piece of mainspring in position, making sure that it " takes." Wash in water, dry off, and then file up, burnishing the fresh surfaces bright. The surfaces will still be steel, but not quite so hard as the original pallets ; this does not matter —they will not groove again perceptibly for years.

When doing any repair of this kind, where new surfaces, new teeth, or other items have to be added, or superimposed, or cut, try to shape them and finish them off so well that the joins are hardly visible. It doesn't matter that the part " won't be seen." Good workmanship is always worth while, and a job left rough means a bad conscience . . . or ought to.

A frayed gut or line should be removed and a new one put in, otherwise its weight will drop sooner or later, when the line breaks. This usually happens in the middle of the night. It is quite an easy matter to put a new gut. Before inserting it, grip one end of the gut in the vice, and pull it to full length ; then with a drop of oil on the gut slide your finger and thumb along it for a minute, being careful not to get any kinks in it. One end of the gut passes through a slot in the rising-board and is tied round a peg ; the other end passes through a hole in the grooved " barrel." After tying a knot in the end that is passed through this hole, cut the superfluous gut away to about half an inch from the knot, light a match, and let the end frizzle in the flame—but do not let the flame touch the knot itself. This makes a " blob " of hard charred gut just beyond the knot, which ensures its safety. Make sure that the gut line does not rub on the rising-board when the movement is in position.

When putting the clock together, rest the front plate upon an open box deep enough to allow the projection of the centre arbor and winding squares. Try the striking before pinning up, and see that the train is stopped by the wing or tail of the gathering pallet directly after the hammer falls. Sometimes you may get it right first time ; but you may have to free the pinion of the gathering-pallet wheel by gently lifting the plate and turning the wheel slightly to alter its relation to the pin-wheel. Also try shifting the gathering pallet on its square. For the adjustment of the warning, instructions are given in the chapter " Thirty-Hour Chain Clock."

## HANDS AND DIALS

The hands of many old grandfather clocks are beautifully designed and finished ; take care of them when they come under your notice. An expert can often make a fairly close estimate of the age of the clock from the style of the hands alone.

As a rule, when the clock has been neglected or is in bad condition, the hands will be rusty. Remove all the rust with emery cloth until you have a nice matt surface. They must then be re-blued. This can be done by passing them slowly through the flame of the spirit-lamp, though care is needed to avoid unequal colouring. A better method is to make a shallow tray of tin or brass, fill it with fine sand, lay the hand on this bed of sand, and heat the tray gradually, watching as the colour of the hand passes through its stages of straw, purple and finally blue. When the blue shade appears, lift the hand clear and let it cool off.

The hour hand usually has a notch corresponding with a pin or projection on the socket of the hour-wheel, indicating its position and preventing it from dropping.

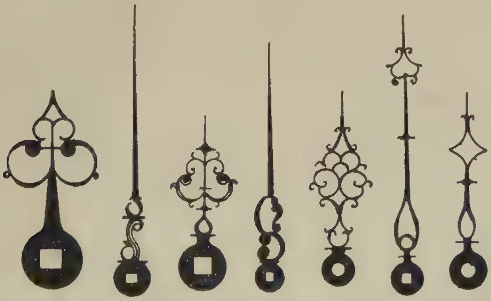

Fig. 17.—Some beautiful old clock-hands.

When replacing the minute hand you will of course put it on the correct square, so that the striking is freed when the hand is at the figure 12. Pin it on, with its collet, and make quite sure that when it is pinned on properly the hour-wheel has a little play or shake. This applies to any clock; an hour-wheel that "binds" takes most of the power off the going train and will soon stop the clock.

The ornamental brass dials of these clocks, often works of art, can be cleaned at home to some extent by first removing dirt and grease with petrol, and then going over them with a pad of tissue-paper moistened with ammonia. The actual renewing and relacquering, if needed, is a matter of skill, and should be left to the firms who undertake such work. My own feeling is that a very bright and new-looking dial spoils the character of these old clocks, and that a moderate amount of cleaning, with the blueing of the hands, is enough.

## THE CLOCK CASE

All clocks, of whatever kind, should stand firmly and squarely wherever they may be placed. This applies with special emphasis to pendulum clocks, and with most emphasis of all to long-case clocks of the grandfather type, where the swinging of the heavy pendulum can cause the case to rock slightly if it is not standing squarely to the floor. If this happens, the clock may stop, or fail to keep good time.

Another and more rare phenomenon is the tendency of the weight to start swinging when it has descended to a point level with the pendulum bob ; the cause of this may be the regular disturbance of the air, also possibly, a sympathetic resonance. At that particular point the weight is in a position to swing in the same period—usually the beat is in seconds—as that of the pendulum, and even the tiny whiff of air from the moving bob, by its repeated periodic impulse, will affect it. The cure for this is to interpose a thin sheet of wood or metal, fixed across the width of the case, between the pendulum and the weight, at the level of the bob.

If you have any aptitude for woodworking, it is usually worth while trying to make the head of the case a closer fit. Often there are gaps so wide, and the glass door is so loose, that all the fluff floating round after a passage or room has been swept can find an entrance into the movement. Even if the use of a vacuum cleaner is the rule and brush and dustpan are abolished, dust rises every time anyone wipes shoes on the mat, and every time you walk across a carpet. (Watch your step in a beam of sunlight.)

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Head of a fine old carved mahogany English grandfather clock; date about 1765. The dial is signed "Davison, Ecclesham." The clock is the property of the Victoria and Albert Museum, London, S.W.7.

A great deal of dust enters the case also at the floor level, and a little amateur carpentry will again be useful.

Remember that apart from ordinary household disturbances, changes of temperature, constantly occurring, cause currents of air which carry minute particles with them, and these will lodge on the clock-plates and adhere to the oily pivot-holes until in time a deposit is formed and clogs the movement ; so the fewer the cracks and gaps in the case the better for the clock. Very few people pay any attention to this. Where the case touches the ground—or should touch the ground—you will often see spaces of half-an-inch or more ; and when the case has no bottom—in other words, is open to the floor—the movement is acting in a cloud of invisible dust all day long. You cannot make these old cases airtight ; but by laying the case on the floor and examining it carefully, then doing a spot of work with strips of wood, glue, and perhaps felt for packing, much can be done to make them fairly dust-tight.

The restoration or repolishing of a good grandfather clock-case should be left to an expert. Some of the older cases are fine, handsome specimens, easily spoiled and lowered in value by unskilled treatment.

## THIRTY-HOUR CHAIN CLOCK

These clocks are fairly familiar objects in the home circles of England ; the case is very much like the eight-day grandfather case, but not, as a rule, so high or stately, and the head is generally square and plain. The movement, instead of having two weights on separate gut lines, is driven by a single weight in the loop of a chain which passes over both main wheels. One of the main wheels has a loose pulley with a click or pawl acting on the arms of the wheel ; the clock is wound up by simply pulling a section of the hanging chain and thus raising the weight. This makes a fearful noise, and should not be done late at night; also, when striking, the chain, which passes over pins on the pulleys of the main wheels (after the style of sprocket

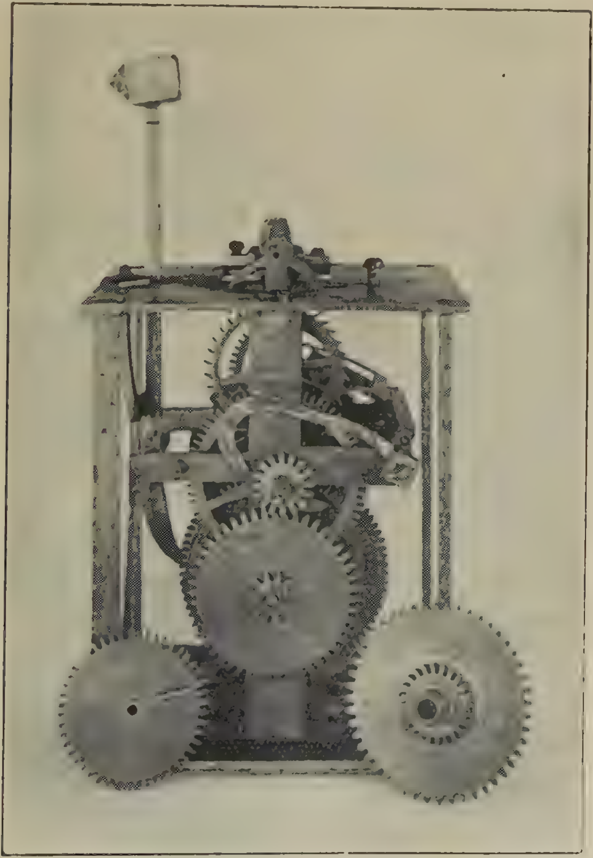


Fig. 19.—One of the oldest types of "bird-cage" English thirty-hour chain clocks. Hour-wheel and month wheel removed. Plates kept in position by wedges instead of pins and pillars. Note the rough bent iron lifting-piece. In this clock the large motion-wheel is driven by the main wheel, fitted on its arbor and kept tight by a slide; there is not the customary centre-wheel.

wheels) often jumps and shakes the whole case. However, these relics of an older civilisation are good, trusty servants, thoroughly British, and well worth looking after. Like the grandfather clock, they will go on keeping time until absolutely brought to a standstill by dirt and dust; and even then a clean-up leaves them as sound as ever.

To start operations, slide the head of the case forward and off. Unship the pendulum. In taking the pendulum off any clock of the grandfather type it is best to put your left hand behind and ease the spring out of its clip while lifting the rod gently with your right hand; this avoids buckling the spring if it happens to stick—as it often does if the clock has not been cleaned for a good many years. Lift off the weight; then lift the movement with its rising-board clear—the chain of course comes with it.

Place it on your bench or table and examine it. Once more I emphasise the wisdom of having a good look at the "works" before you *do* anything. Note, with this type of drive, the *direction* in which each train runs, and that the chain is so arranged that the pull of the weight in the loop between the two main wheels impels both the striking and the going train in the proper direction. It is annoying after having finished and set it up, to find the minute hand travelling backwards.

Unpin hands and dial, remove the bell, and take out the pallets by unscrewing the bridge on back plate. Drive the striking train round by pushing its main wheel, and watch its action carefully. It is very different from the rack mechanism of the eight-day clock. Note that the second wheel of the train has a brass circle attached to it, with a gap into which one of the inner arms of the count-wheel lifting-piece dips directly after the hammer has fallen, but that until the slot in the count wheel lets it drop more deeply the striking continues. When the count wheel, as it revolves, brings one of its slots beneath the outer arm of the lifting-piece, this inner arm naturally can drop a little farther, and the striking train is stopped abruptly by the edge of the gap in the brass hoop coming against its squared head. Careful attention to the action of the striking train will save a lot of trouble when you put it together.

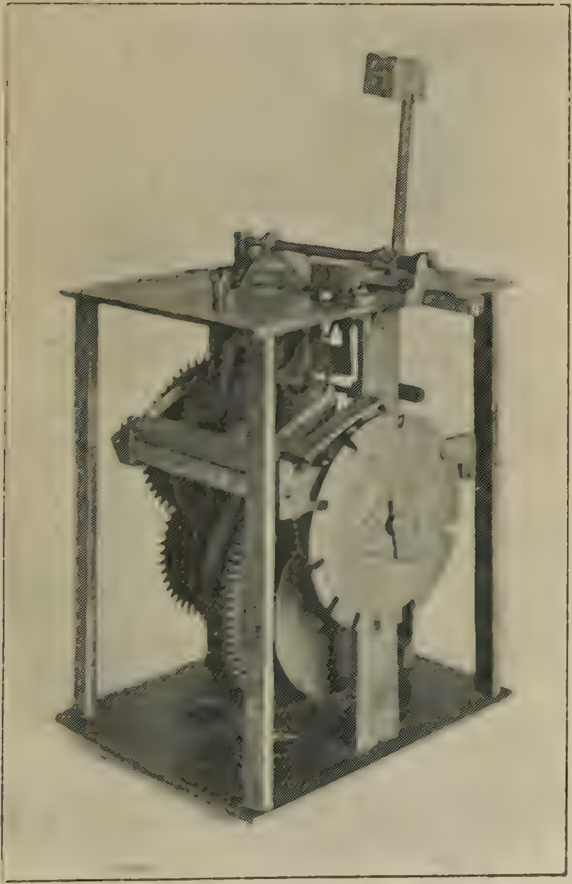


Fig. 20.—Back view of fig. 19, showing count-wheel, also method of mounting the pallets.

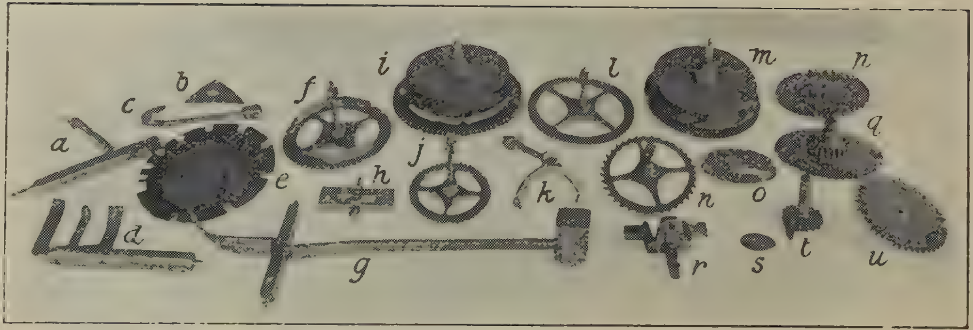


Fig. 21.—Parts of English thirty-hour chain clock shown in fig. 19.

*a*. Lifting-piece. *b*. Count-wheel spring. *c*. Part of *a*, fitting on squared end. *d*. Count-wheel lifting-piece. *e*. Count-wheel. *f*. Cam-wheel of striking train. *g*. Hammer. *h*. Fly. *i* and *m*. The two main wheels. *j*. Warning wheel. *k*. Pallets. *l*. Second wheel of going train. *n*. Scape wheel. *o*. Slide to tighten dial work. *p*, *q*. Motion and hour wheels. *r*. Pallet bridge. *s*. Collet for dial-work. *t*. Cannon pinion. *u*. Day of the month wheel. Small pinion that drives count wheel is not shown.

The third wheel of the train carries a pin—the "warning" pin. When the train is stopped after the hour has struck this pin must be about half a revolution away from the bent part of the warning lifting-piece (A) which projects into the movement from the front plate and is raised at the approach of each hour by the pin (C) on the motion wheel (fig. 22). When this occurs, a minute or two before the hour, the train is freed, because the inner lever is then lifted clear of the circular rim attached to the second wheel of the train ; but until A drops off the pin C the train is held up. It revolves, however, to the extent of half a revolution of the warning wheel, the pin of which then stops it by coming against the warning lifting-piece. This causes the momentary buzz or "warning" before the hour strikes.

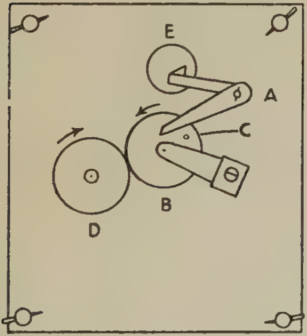


**Fig. 22.—Front plate of ordinary thirty-hour chain clock, bridge of centre wheel removed.**

A. Lifting-piece. B. Motion-wheel. C. Pin which raises A. D. Minute-wheel, driving B. E. Hole or slot through which end of lifting-piece projects into the works to engage pin of warning-wheel.

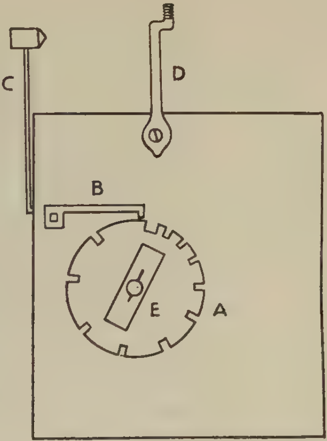


**Fig. 23.—Back plate of fig. 22.**

A. Count wheel or locking-plate. B. Outer part of lifting-piece. C. Hammer. D. Bell support. E. Flat brass spring kept in place by pin passing through stud.

Unpin A, and take off the motion work ; do not overlook the small flat brass spring between the front plate and the minute wheel. It is the pressure of this little spring which carries the minute wheel round with the long arbor of the centre wheel (see fig. 12). Unpin the count wheel and its lifting-piece; the pinion that drives the count wheel is often kept in place by the flat projecting rim of the wheel, without any pin or screw. You then have the clock under bare poles, as it were, and can remove the four pillar-pins and lift off the plate.

It is as well to keep the wheels of the two trains separate until you are familiar with them and with their positions.

Proceed for cleaning and repairing as with the eight-day grandfather. Put in any new holes that may be necessary. Let the chain have a good bath of petrol—it will probably need it. If it is badly worn, or badly fitted in the first instance, you may have to get a new one; these can be bought ready to put on, of the right length, but the main wheel should be taken when purchasing a new chain in order to make sure that the links are the right distance apart. To place it in position is a simple operation. You want to remember two things—the direction in which each main wheel revolves, and the way the loop of chain between them hangs in order to give the right pull. If by chance you find that you have put the chain on and omitted to place the weight-pulley in the loop, just open one link, slip the pulley on, and rejoin.

Special repairs to a clock of this type are generally confined to the striking side; but there is one rather awkward job which I have sometimes found necessary in connection with the clickwork. This is very primitive, the arms of one of the main wheels forming the stop or ratchet, while the "click" itself is a circular springy piece of steel, very stiff, with a deep notch which passes over each arm with a nasty jar as you pull the chain to wind the clock. There is a considerable strain on this circular piece, and it often requires re-riveting, as it takes half the direct pull of the weight. To do this you should take the sprocket off its arbor—it is usually kept in place by a pin. If necessary, punch out the old rivets and put new ones, and don't be afraid to rivet them well home. Replace the sprocket and try the clickwork ; if the rivets show the slightest looseness do the job again. One is often tempted to say "that's good enough" ; but the temptation should never be yielded to ; remember that the weight is pretty heavy, and that sooner or later a faulty clickwork of this sort will give way, and make a lot of trouble. Another point to note is that the edge of the click must act squarely against each arm of the wheel, with no tendency to slip. A slight grooving or cutting of the arms is of no consequence, the wheel being very substantial ; in fact, it is in a way beneficial, the click having worn a path for itself, and thus made the

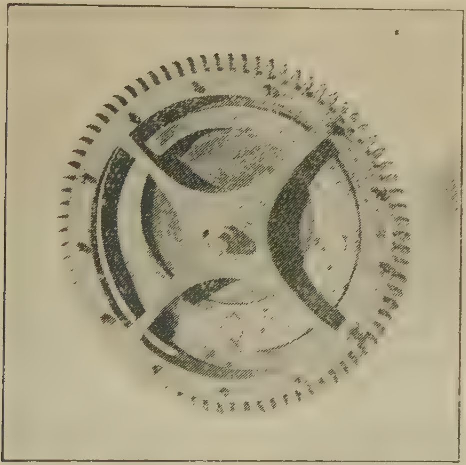


Fig. 24.—Main wheel, striking train, of English thirty-hour chain clock, showing the circular click and spring in one piece bearing on the arms of the wheel.

winding smoother. Fig. 24 is a photograph of one of these wheels; the edge of the click can be plainly seen close to the upper arm of the wheel on the left.

## THE ENGLISH DIAL

The "English Dial" has made a name for itself, and a more satisfactory clock for general purposes it would be difficult to find. It is plain and good; hardly suitable for the drawing-room, but excellent for the hall, for a library, lounge, or school, or any place where a clear indication of the time from a distance is desirable. The case may be circular, or it may have a drop piece or "trunk" beneath, according to the length of the pendulum; and it is usually of some sound, strong wood such as mahogany.

The movement, you can see at a glance, is excellently made and well finished. To take it from the case, first remove the pendulum—open the doors at bottom and side and lift it off with one hand, guiding it free with the other; then remove the hands, and pull out the wooden pegs at the sides. The back or box will then slip off easily, and you can pull out the pins of the dial pillars and take out the movement, leaving the dial in position, fixed to the case. There is no need to disturb this.

The movement looks very simple, though it is not, perhaps, quite as simple as it seems at first glance. You may not have seen a clock with a fusee before, driven by a chain or gut instead of directly by a toothed main wheel or a going barrel; so consider the whys and wherefores carefully. A mainspring, naturally, is at its strongest state of power-giving when fully wound up; when nearly run down it is quite weak. This of course you have noticed hundreds of times when winding the house clocks. (That is why a weight is better than a main-spring as driving-power—it gives the same pull all the time.) The fusee is an ingenious device to equalise the pull of the spring. The spring is contained in the wide, smooth barrel, and its pull is transmitted to the train, *via* the fusee, by a gut or chain. When fully wound, this chain is entirely on the fusee with the exception of the short piece leading to the barrel and a half-turn or so on the barrel itself, and the pull is taken by the fusee at its smallest diameter (fig. 25). As the spring runs down, the pull, gradually growing weaker, is taken by the fusee at its larger diameter, until at the end of the week the pull is on the last groove of the fusee, which is of a diameter almost equal to the barrel itself. The leverage is thus continually and proportionately altering, and the actual power transmitted to the scape wheel and pallets remains fairly uniform whether the clock is just wound up or nearly run down. When the spring is in the first flush of its youth, as it were, some of its ardour is checked; when it is getting old and declining in strength, it has its work made more easy. We must not carry the analogy any farther—for the spring can be wound up and start again, while we can't.

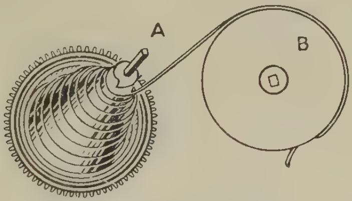


Fig. 25.—Fusee and barrel of English dial (fusee shown in perspective). Position of line when clock is fully wound. Barrel ratchet removed.

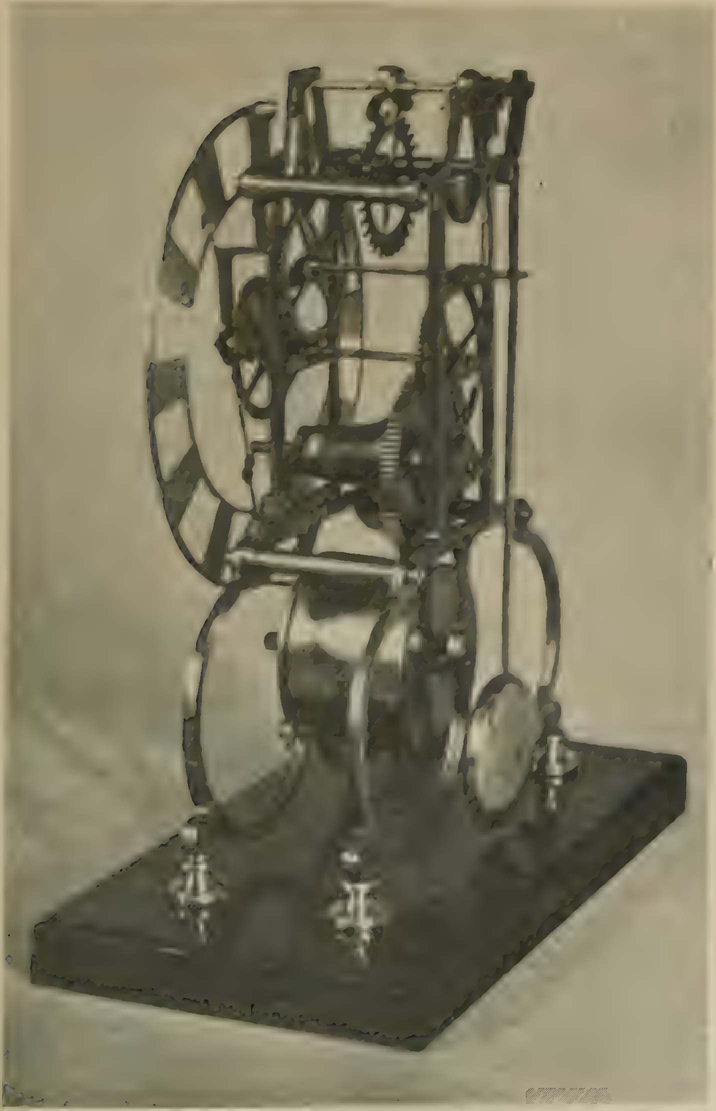
A. Winding-square. B. Barrel.

To take the movement to pieces, remove the pallets and let the train run free, giving the scape-wheel pivots a drop of oil if they are dry. When the wheels stop running, the chain or gut will be off the fusee and on the barrel. You will notice, however, that there is still some pull on the gut ; this is due to what is called " setting up," and the pins must not be removed from the pillars until the spring is right down. Grip the barrel arbor square (not the winding-square of the fusee) in a hand-vice, raise the click, and you will be able to let the vice revolve in your hand until the power is entirely off and the gut is slack. It will probably be hardly a full turn, so there is no danger of a slip if you hold the hand-vice firmly. You can now remove the vice and take the plates apart.

Cleaning is done in the usual manner, but a clock such as this should be nicely polished. The barrel cover should be taken off—prise it off with the end of a file or an old screwdriver inserted in the little notch. Clean the barrel arbor and the holes, but do not attempt to take out the spring ; these springs are wide and strong, and not easy to replace in the barrel without some practice. Give the spring a couple of drops of clock oil ; these will distribute themselves among the coils and prevent sticking.

It is just as well to take the fusee to pieces ; remove the cap, and clean the parts properly, giving the chain a bath in petrol. If the clock has a gut line, this should be simply wiped with an oily rag.

After drying off, get the plates pegged out until you can push a pegwood into every pivot hole, twirl it, and find it spotless. If the plates need polishing, this must of course be done before pegging, using whatever method seems indicated by their condition, and finishing with a medium brush charged with chalk, or with some form of metal polish. You will often find, however, that these movements are in such good condition, owing to their well-fitting cases, that hardly any polishing is wanted—the plates come up bright with the merest rub of a dry duster.



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A beautifully finished skeleton clock.

Give the click of the fusee a little oil before reassembling, and see that the gut is not frayed. Then put the clock together again—a simple matter.

To "set up" the mainspring, so that when the *clock* is run down the *spring* is not run down, put on the ratchet of the barrel arbor and its click, but do not screw the click up tightly. If the clock has a chain, hook it in its barrel hole or notch, and turn the barrel by its arbor slowly until nearly all the chain is wound round the barrel, guiding the coils with your other hand; then hook the other end of the chain in its place in the largest groove of the fusee, and continue to revolve the barrel until the chain becomes taut. Now wind up the spring by the *barrel arbor* to the extent of six or seven teeth of the ratchet, gripping the square in hand-vice or large pliers, and screw the click-screw home.

Follow the same procedure if the clock has a gut, except that there is no hooking to be done, the gut being already fixed in barrel and fusee.

The object of setting up will be plain after a moment's consideration. If the spring were to run completely down when the line reached the end of its course, there would be no tension on the line and it would slacken and slip off the barrel. Also, by setting up the spring we ensure that there shall still be a fairly strong amount of driving power even at the final turns of the fusee—equivalent to the end of the week when the time for re-winding approaches.

In a clock of this description the spring is wound up by turning the fusee, the barrel arbor remaining stationary between the plates, fixed by its substantial ratchet-work. Therefore, since we cannot see, when winding the clock, the position of the line on the fusee, there must be some device for preventing overwinding and a possible broken line. You will have noticed between the plates a jointed projecting arm of steel with a notched edge, held outwards by a weak spring; this acts in conjunction with the projecting knife-edge on the fusee, close by its smallest groove. When the last coil is coming off the barrel as the clock is being wound, it presses the stop-piece inward until the fusee-piece catches against its notched end and stops the winding dead. There are other forms of stopwork, but this is one of the neatest. A precisely similar stopwork is seen in verge watches and in many English lever watches.

Having set up the spring, and screwed the click down firmly, put the pallets in, and wind the clock up, with key on the fusee arbor (which is, of course, the winding-square that shows when dial is on) in the usual way, but slowly; and as you do so just guide the chain or gut into the fusee groove as it comes off the barrel; any smooth tool or handle will do. It needs this guidance only for the first occasion of winding; as the clock runs down in the ordinary way the line, coming off the fusee, settles into its correct place on the barrel. In fact most barrels of this type are marked quite clearly by the constant pressure of the line or chain in the same place.

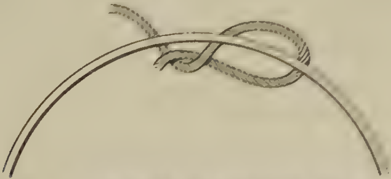


Fig. 26.—Method of fastening gut line in barrel of English dial.

You have probably noticed, when winding up the clock, that it still "ticks," even though, obviously, you take all the power of the mainspring off with each turn of the key. This is due to the device known as the "maintaining power," a secondary ratchet-work so designed as to give a little driving impulse, merely for a minute or so, by means of a small and slightly compressed spring. It comes into action, on the fusee, immediately the power of the mainspring is taken off during the operation of winding, and it prevents the train from momentary stoppage and a possible trip of the pallets on the points of the scape-wheel teeth.

The movement of the "skeleton clock" is in all respects similar to that of an English dial. These clocks are generally protected from dust by a glass dome, and are nearly always in excellent condition. For cleaning and putting together proceed as for the English dial. The apparent differences are due to the spaces between pivots being cut away and the plates shaped into ornamental curves.

A new gut, if required, should be stretched and oiled in the same way as mentioned in the section on "Eight-day Grandfather" clocks. It is inserted in the barrel, using the three holes, as shown in fig. 26, and the loose end is charred in a match-flame. This makes a fastening, as you can see, that will never pull out.

## GERMAN DIAL; AMERICAN DIAL

No special instructions need be given for the cleaning of these clocks; follow the rules for cleaning eight-day grandfather clocks, with such modifications as may seem advisable, having regard to the condition of the movement.

These movements are satisfactory timekeepers, though differing greatly in finish, and in appearance, from the high-class English dial. In taking to pieces, unpin the minute hand, and lever off the hour hand, which slides on friction-tight. The dial may either be screwed or pinned on, and the movement is generally screwed to the case.

You will notice that the mainspring is visible, the inner end being hooked directly on the main-wheel arbor, the outer having a loop which slips over a pillar. Before letting it down it must be controlled, otherwise it opens out very much, and it is difficult to put the clock together when it is fully unwound. Wind up nearly fully, and either tie it round securely with thick string (including of course the pillar) or slip over it a three-quarter circle of thick iron wire. The latter is much the better plan, and suitable pieces of wire are found on new mainsprings for this type of clock, when purchased at the dealer's. The spring can then be let down as far as it will go, and fills the clamp snugly without spreading to an unmanageable size. Or you can remove the pallets and let the train run down till the power goes off.

The pendulum spring and wire of the pendulum are generally in one piece, the " spring " being merely a flattened and thinned end of the wire. This thin end is gripped in a slit brass stud, which can be slightly opened by the blade of a knife.

There are one or two points to be careful about before putting the clock together. The hands of these clocks generally depend for their tightness on a little spiral spring on the arbor of the centre wheel, kept in place by a pin and collet ; this keeps the arbor friction-tight against the wheel. If it turns very easily the hands may fail to move although the clock is going. Unpin the spring and extend the coils, then repin it ; this will cure the fault. If there is a flat spring, make it more bow-shaped, and repin it.

To put a new mainspring is very easy. It is already in an iron clamp when purchased, and the clamp is left on. Slip the arbor into the spring centre, and see that the hook on the arbor enters the hole of the spring and catches it up ; then place the main wheel, with spring attached, in position. When, finally, you wind the clock up in the usual way the iron clamp will drop off as the spring contracts, and it should be saved for future use.

The pallets of these clocks are carried on a riveted tongue of brass bearing a steel pin (fig. 27) ; this can be moved with pliers if the depth of the escapement is not correct. The correct position for the pallets is as close to the scape wheel as possible without tripping on the points of the teeth. If the acting faces are badly cut, it is possible to bend the arms of the scape wheel very slightly and thus bring the teeth to drop on an unworn part of the pallet face; but I do not recommend this. It is far better, though a little more trouble, to bush the wheel forward or back a trifle. I have seen it done by a third method—the interposition of a collet on the pivot between the plate and the shoulder of the pivot; but this can only be done when the wheel has plenty of endshake, and in any case it is a clumsy trick and increases the friction, so should be avoided. This "dodge," like knocking up a hole with a punch, or soft-soldering when nice clean riveting is called for, is a sign of laziness and bad workmanship.

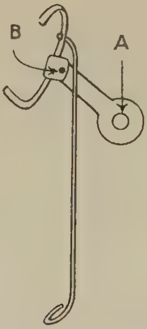


**Fig. 27.—Pallets and crutch of American clock.**
On bridge riveted to plate at A, pallets swinging on pin at B.

New holes, if needed, can be put in, the method having already been described. Very frequently the scape holes of these clocks are almost big enough for two pivots. A larger pin may be necessary for the pallet-bearing, which sometimes allows the pallets to rock sideways in a pathetic manner; this may be made from a needle, brightly burnished, or from steel wire.

When the movement is replaced, and the pendulum spring in position (the slit that holds it having been closed again by a steady pressure with nippers), see that the rod hangs free in the loop of the crutch, centrally, but that it has not much play. Hook on the bob of the pendulum, and, after winding, watch the action for a few minutes to discover any little fault. If such a moving part as the crutch or pendulum rod touches any fixed portion of the case or dial the clock will of course stop at once.

German and American striking dials seem rather a closely-packed mass of wheels and wire to the uninitiated, and the action of the striking side is not so clear as it is in clocks of better make with solid plates, higher finish, and shaped lifting-pieces of steel instead of bent wire. The whizzing noise betrays plentiful friction, too. But if you will only keep calm, pull yourself together, and remember the principles of the count-wheel striking mechanism, there is no reason to doubt your ultimate success. You will not be dismayed when confronted with a count-wheel of unusual diameter, having two sets of twelve hours instead of one ; nor will a variation in the position or shape of the lifting-pieces cause more than a momentary terror.

I need not describe the movement of these striking dials in detail ; to do so would simply mean unnecessary repetitions. There are a few differences to be noticed. The count-wheel is generally between the plates. Lifting-pieces are made of wire, and their action is often a bit "springy," instead of nice and "solid." If wrongly bent, the striking may give some trouble after the clock is put together ; the train may jump on from hour to hour, refusing to lock. This is where patience, pertinacity, and a little deduction come in. See that the flattened end of the arm that drops into the deep slots of the count-wheel drops in centrally and does not rub either side of the slot. If it is correct, but still jumps out at the end of the hour, the fault probably lies with the inner wire which stops—or should stop—the train and a slight bend, in a direction which your own observation will indicate, will set this right. It is a fact, however, which every watchmaker's apprentice knows to his sorrow, that the striking of these comparatively rough movements can be quite troublesome, once it gets out of adjustment; therefore before you begin bending any lifting-pieces I advise you to work out well in your mind the probable result of your action, trying the hours round repeatedly until by close inspection you have arrived at a definite conclusion. Even if this proves to be insufficient, or wrong, it is infinitely better than bending something at haphazard in the hope that the clock will then strike right. Lots of people do this, and get dreadfully mixed up. Never bend a lifting-piece without thinking out your reason. This may seem much ado about nothing; but I know these clocks. Once they get annoyed they can worry you for hours.

## NICKEL ALARM

The nickel alarm has no beauty to recommend it, either of face or figure—the one being made of paper, the other merely circular. Its object in life is to tell the time moderately well, and to wake people up with extreme efficiency when necessary. It will stand plenty of hard knocks without protest, and for kitchen, maid's room, nursery, and other places where a fine movement would probably fail, it gives great satisfaction. It has many varieties; but whether plain drum, or square, or on a wooden base, or in a wooden frame, the movement, once understood, is pretty well the same and is easily dealt with by the amateur.

In the ordinary drum type the set-hand pieces, keys, feet and bell support must be removed before the movement is free. Turn the keys backward; they will unscrew and drop off. Pull the little piece that sets the hands straight off, and unscrew the alarm-hand set-stud if necessary; then the other fittings can be unscrewed. As the nickel case is often rather springy and the circular iron ring of the dial a tight fit, some patient " wangling " may be needed to get the works out. Pull them out from the bottom, and bend the wire of the hammer a trifle if necessary, in order to slide it clear of the slot at the top.

Remove the minute hand, which is simply knocked on tightly, with nippers, and take off hour, alarm, and (if there is one) seconds hand carefully, because the dial is generally paper on zinc and is easily scratched. A couple of screws or nuts attach the movement to its ring support.

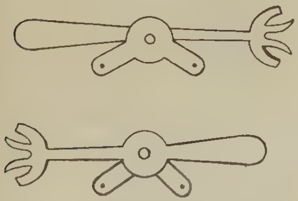


Fig. 28.—Pin pallets and lever.

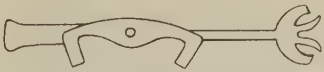


Fig. 29.—Ordinary pallets and lever.

You now have before you, on a large scale, in the escapement, the principle of the lever watch ; so it is worth while pausing to examine the action. If the pallets are simply pins, and the scape wheel has club teeth, the action is practically the same (fig. 28). The lever, attached to the pallet staff, has a fork with two horns ; a pin on the balance wheel, very near the centre, enters this fork at each swing of the wheel, moving the lever up and down alternately and liberating a tooth of the scape wheel at each swing. A part of the balance staff is cut away to allow the horns of the fork to pass.

The hairspring, its centre collet fixed (by tightness) to a shoulder on the balance staff, and its outer coil pinned into a stud or small projection on the plate, brings the balance back beyond its middle position of equilibrium at every stroke, the impulse that keeps it continually vibrating being transmitted from the inclined planes of the scape wheel teeth, *via* the lever, to the pin on the balance wheel.

The pallet faces are transferred, as it were, to the scape-wheel teeth, in an escapement of the pin-pallet type ; but many of these nickel clocks have " real " pallets, similar to the pallets of a pendulum clock, and a scape wheel with pointed teeth acting in the usual way.

(South Kensington Museum has a large-scale working model of the lever escapement, with a balance wheel about eight or nine inches in diameter, well worth close inspection. It shows the action of the three essential components—the scape wheel, lever, and balance—admirably.)

There being no winding-square, let the mainspring down by taking out the balance and pallets and allowing the train to run ; clamp the mainspring as usual. The balance is poised between two screws whose ends are slightly drilled to receive its sharp, pointed pivots ; you can lift it out, after taking out the flattened pin of the hairspring and drawing the coil through the hole, by loosening one of these screws. The pallets may or may not have a movable bridge ; if not, by removing the pillar-nut nearest to them and loosening one or two of the others, and then lifting one corner of the plate, it is easy to take them out for the train to run free. The clock is then ready to be taken to pieces.

Clean in the customary way, except that no polishing is required. Before putting together see that the tightness of the centre wheel and of the alarm arbor is right. If the alarm arbor is too loose, the alarm hand will move round with the other hands ; it can be tightened by springing the collets or washers, which generally hold it, a bit more, then repinning it. It must move quite stiffly.

Replace the dial, and set the alarm. Wind up the spring of the alarm side a turn, then put the alarm hand on, just pressing it into position, and turn the set-hand square till the alarm goes off. Push the alarm hand round to an even hour—say, nine o'clock—and put on the other hands at nine o'clock ; then press or tap the alarm hand on firmly. The alarm should then ring at whatever time it is set. A tap with a light hammer, with the set-square resting on the vice, is the best way of fixing the alarm hand and minute hand. Be sure that the hands are all free—that is, that the hour hand does not catch in the alarm hand ; if it does this, or very nearly does it, it must be slightly bent upwards at the socket and downwards again a fraction of an inch away from the socket—to keep it parallel with the dial.

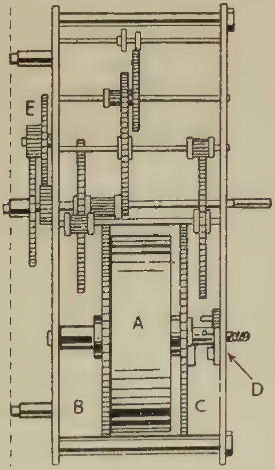


**Fig. 30.—Movement of nickel alarm with alarm driven from going mainspring. Balance and set-alarm arbor omitted. Dotted line shows position of edge of dial.**

A. Circular rim without cover containing mainspring, fixed to B, main wheel of going train. C. Main wheel of alarm train. D. Ratchet-work attached to inside of back plate. E. Motion-work.

If, when you have the clock together, the hairspring pinned in as before, it does not go when wound up, the fault is almost sure to be in the escapement. Examine the balance for end-shake ; it must just be free, but without perceptible play. Make sure that there is no roughness, no grooving, on the conical pivots of the balance wheel ; if there is, they must be made perfectly smooth and burnished.

The hairspring must be free between the loop of the regulator. When the balance is at rest, the pin should be in the centre of the fork, and a slight movement of the balance either way, with the finger, should allow a tooth of the scape wheel to pass. Pull the hairspring in a trifle, or let it out, as indicated, if the pin does not rest in the centre of the fork. If one of the pins of the lever is bent, the teeth of the scape wheel may either fail to pass it, or may run past it at a great rate. With a small pair of pliers straighten the faulty pin. A broken pallet pin can be replaced by one made from a fine needle ; it must match the other in thickness, and be burnished smooth.

One often hears the remark, with this type of clock, " The regulator is right over to ' fast,' and it still loses." This is easily altered if you know how, but the method is not generally mentioned in books of instruction. You can see with a moment's thought, that if you pull the hairspring in a bit and repin it, the effect is that you have shortened its acting coils. Therefore the clock will go faster because the balance will make a greater number of vibrations in any given period. But you can also see that by doing this you will put the clock badly out of beat ; the pin will be anywhere but in the centre of the fork when the balance is at rest. This, then, must be corrected by *moving the hairspring round* on the balance staff—which for the amateur is a rather tricky operation. You will see a wedge-shaped cut in the hairspring collet, at the centre. If you insert your watch screwdriver into this, and press steadily, it will hold the hairspring while you turn the balance staff a little with the other hand. It needs care, that is all, and may have to be done two or three times before the clock is exactly in beat, though if you prefer you can make the final adjustment by pinning the hairspring. The process is reversed if the clock gains persistently—that is, if there is any spare part of the outer coil to be " let out." If the whole of the hairspring is in action and the clock still loses, the best remedy is a new hairspring. A hairspring can be scraped with a graver to weaken it, but this is hardly worth while, and in any case is not very satisfactory.

## A FEW WORDS ON THE HAIRSPRING

One of the troubles frequently met with in clocks of this class that have had a good long spell of rough usage, is a hairspring out of shape. Some of the coils may be too close together, may even touch one another when the clock is in action ; or the spring itself may ride at an angle with the balance instead of nice and level. Either of these faults is bad for timekeeping, and may be a cause of poor action or even a stop.

To reshape a distorted hairspring requires patience, steady hands, and that invaluable quality common sense. Take it right off the staff, either with a small pair of pliers (being very careful to grip the edge or rim of the brass collet only and not the central part of the spring itself), or by easing it free from behind—but mind the pin of the balance. Peg it down by a short piece of pegwood through the centre, with a piece of white paper beneath, the peg fitting into a hole in the bench or in any firm flat piece of wood—the object being merely to hold it steady. Now, with tweezers in one hand, and a large blunt needle in the other (this should be fixed in a wooden handle or held in the pinvice), open out the coils that are too close, working from the centre outward. Hold the coil you are dealing with at a suitable place with the tweezers, then with gentle stroking movements away from the tweezer-points draw the needle along the coil to open it slightly. The idea is to avoid above everything a sharp *bend* of the spring.

You will perhaps find that this has brought that particular coil too near to still another coil. Repeat the process patiently until the spring as a whole is in a fairly good spiral shape with its coils equidistant from one another—except the outer one, which as you know is spaced wider than the others in order that it may pass through the regulator loop and be pinned in.

If the spring is in good shape, but not flat, it will wobble unpleasingly. The trouble is usually at the centre, where it is pinned into its collet. Examine this, and using your judgment, see if the centre end of the spring has been pinned in a trifle out of line. It is tricky, but not very difficult, to push the short pin nearly out of its slanting hole, move the pinned-in centre end of the spring slightly, and tighten the pin again.

For these little worrying jobs you may find the eyeglass helpful. And if you are tempted to be impatient, think of the watch repairer who has to reshape the hairspring of a wrist-watch !

If you find that a hairspring is even slightly sticky—as many of them are owing to half-dried oil and dust adhering to the coils—let it stand for a minute in a saucer of petrol to remove all traces of oil ; it will soon dry off. A sticky hairspring is a nuisance ; coils may touch momentarily and then jump apart, which spoils timekeeping and may cause stopping when the mainspring is partly run down and the driving power reduced.

## VARIETIES OF ALARM

Movements of the type common to the all-nickel alarm are sometimes found in square portable cases, with glass sides, forming a cheap type of carriage clock. In some of these there is only one mainspring, which drives both the going and the alarm train, a second main wheel being set on the winding arbor. In order that the spring may not run completely down when the alarm goes off, there is quite an ingenious arrangement which prevents the alarm main wheel (which is the same size as the main wheel of the going train) from making more than one revolution. On the back plate of the clock, just inside, is a second ratchet work, the click being attached to the plate, the ratchet to the winding arbor. A pin projects at right angles from this ratchet and engages with another pin on the arbor. When the clock is wound, the pin on the arbor simply carries this ratchet round and, of course, remains practically touching the pin on the ratchet when the spring is fully wound ; but when the alarm goes off, the pin on the arbor, travelling round, comes up against the pin on the ratchet, naturally, after the arbor has made one revolution, and takes all the power off the alarm train.

The alarm train in such a clock as this has an extra wheel, between the main wheel and the alarm scape wheel ; if it were not for this, the alarm, being driven by the comparatively large mainspring of the going train instead of by a small and much weaker spring of its own, would run down at a furious rate and soon spoil its scape teeth if frequently in use.

There is fitted to these clocks a little stop-piece acting on the wire of the hammer, with an index on the back plate, which can be pushed over if the alarm is not needed ; otherwise, as you cannot wind the clock up without also winding the alarm, the alarm would ring once in twenty-four hours—it would run itself down as far as the stop-pin on the ratchet the first time the hour came round, and the second time would of course be mute.

## WOODEN CASE ALARM

These " kitchen mantelpiece " clocks—it is their usual position—are so primitive and rough that it is a wonder they go ; but they do go, and not at all badly, even when the holes are worn to twice the proper size. The case acting as a sounding-board, makes their short "tock, tock," very loud, and when the alarm is used it generally, for the same reason, wakes the people next door. The bell is usually screwed directly on the back of the case.

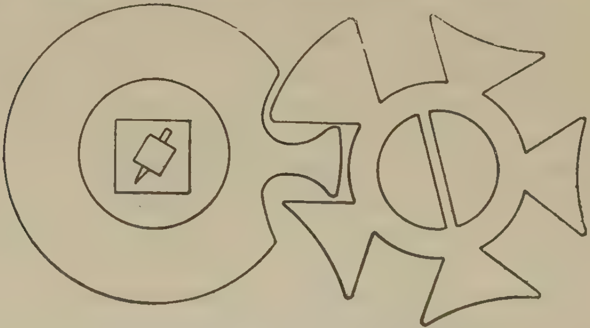


Fig. 31.—A common form of stop-work.

No special instructions are needed for cleaning or repairing this type of humble servant; but the alarm may be explained briefly. There are only two wheels in the alarm train—the main wheel with its spring, and the scape wheel which actuates pallets not unlike the pallets of the going train. Being, of course, uncontrolled by any pendulum, these alarm pallets, to a wire on which the hammer is attached, are free to vibrate quickly when the train is liberated. The principle is so obvious that it hardly needs description. A flat brass ring, numbered from 1 to 12, fits friction-tight over the hour wheel and travels round with it. It carries a rim with a slot or nick, and on this rim rides a wire attached to the pallets. Ordinarily, this stops the pallets from moving; but when the slot comes round they have room to run, and, provided the alarm mainspring is wound, the alarm "goes off." Setting to the hour is done simply by turning the ring by hand from the front of dial, until the hour required is beneath the hour hand.

On the square of the alarm main-wheel arbor you will sometimes find stopwork fitted. Put the key on and wind; you will see that it prevents the spring from being fully wound, also from running completely down, so that the alarm does not keep sounding for an unconscionable time. When putting together, wind the spring up for a few turns before replacing the stopwork, then put it on in the position shown.

## THE DUTCH CLOCK

The Dutch (generally German) clock, with its " plates " of wood, is an easy subject, and rather interesting. The movement is so constructed that some of the wooden

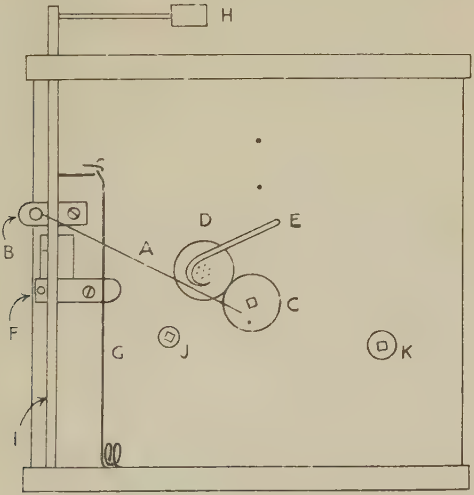


**Fig. 32.—Dutch or German clock with wooden plates.**

A. Wire lifting-piece. B. Pivot of A. C, D. Minute and motion-wheels. E. Wire keeping D in place. F. Hammer lifting-piece pivot. G. Wire spring of hammer. H. Hammer. I. Hammer spindle. J, K. Winding squares of striking and going train.

uprights, containing brass bushes for the pivots, can be removed ; this facilitates putting the clock together.

When a clock of this description is driven by springs instead of weights, there may be no separate barrel ; the two mainsprings are contained in circular brass cases, without covers, screwed to the back of the front " plate." Other peculiarities of construction will be noticed. The lifting-pieces, instead of being pivoted, are drilled at the ends, and pins pushed through the wood serve as bearings for them. The count-wheel lifting-piece is merely a bent and flattened wire. The hammer arbor may be upright instead of horizontal, and extend the whole height of the movement, its spring being simply a long piece of thin wire, coiled at one end, which links into a hooked projection

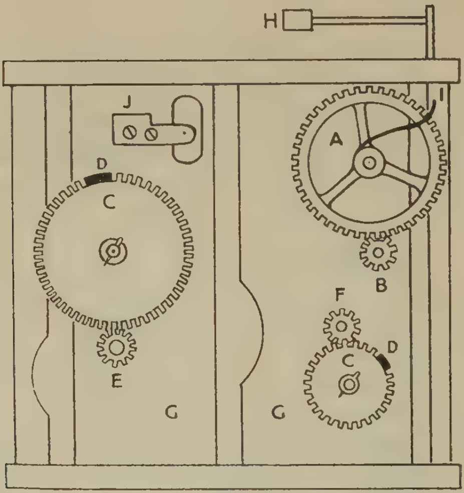


**Fig. 33.—Back view of previous figure.**

A, B. Count wheel and its driving pinion. C, C. Stopwork. D, D. Blanks of stopwork. E. Rear of main going arbor, with pinion gearing into C. F. Rear of main striking arbor, with pinion gearing into C. G, G. Movable wooden plates. H. Hammer. I. Bent wire keeping A in place. J. Pallet bridge.

of the arbor (fig. 32). The stopwork is outside the framework at the back, and consists of a wheel with a space of two or three teeth left solid, driven by a pinion on the rear of the winding-square ; when the solid piece comes round in course of winding, it stops the winding as soon as it touches the pinion (fig. 33).

The whole design is primitive, but the time-keeping as a rule is fairly efficient.

Cleaning a Dutch clock needs no instructions beyond those already given. When putting on the stopwork, see that the blanks in the large wheels allow the spring to be nearly fully wound ; wind the spring up a turn, then slip the wheel on in such a position (the blank being close to the pinion) that it is prevented from running down. The winding-up can then continue for one complete rotation of the wheel, when the blank will have reached the other side of the pinion and will stop the process.

A frequent fault with these clocks is too much play of the pendulum rod in the crutch ; this is altered in a moment, the crutch being merely a loop of wire.

The back pallet hole is usually carried by a bridge, and this hole, when badly oval, should be repaired in the proper manner ; often it will be found very much worn.

The striking is invariably of the count-wheel type, and it should be set right in the customary way, leaving the hammer clear of all lift at the end of each hour.

## FRENCH STRIKING CLOCKS

This type of movement is found chiefly in marble cases, highly ornamental gilt and fancy cases, and, less often, in wooden cases of the " drum " shape. Its mechanism, being packed into a small space, looks complicated, and until the reader has gained some familiarity with clock work by experience with larger and less delicate movements he should not attempt to take a French clock to pieces.

The movement is gripped in the case as a rule by two long screws, which pass through holes in a loose circular bezel or ring at the back, and enter two long strips of brass attached to the framework of the dial. Before unscrewing them, unship the pendulum; you may have to remove the bell first. If the hammer strikes on a gong, the pendulum can be lifted out through the centre of the gong, which is bolted to the base of the clock.

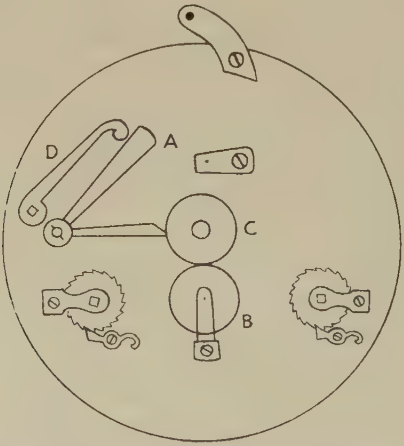


**Fig. 34.—French clock, count wheel movement. (Front plate.)**

A. Lifting-piece. B, C. Motion and minute wheels. D. Lifting-piece raised by A.

Slide the movement out from the front. Unpin hands and dial; then slip the hands on again, without pinning them up, and strike the clock round. Take a good look at the striking gear; look at it for half-an-hour if necessary (it may save vexation later on), and note, if it is a count-wheel action, that the principle is precisely the same as that of the thirty-hour chain clock previously described, the differences being merely due to the different position of the various parts (figs. 34 and 35). Instead of the wheel carrying the brass rim, the gap in the rim stopping the striking train at the end of its run, we have a wheel with a pin in it serving exactly the same purpose. Note that the hammer falls when this pin is several teeth away from the squared edge of the lifting-piece ; also, that there is a " warning " pin on the wheel next the fly, and that this pin must be half a revolution away from its lifting-piece when the train comes to rest.

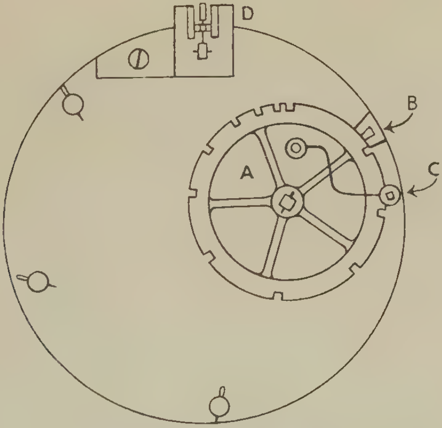


**Fig. 35.—French clock, count-wheel movement. (Back plate.)**

A. Count wheel or locking-plate. B. Knife-edge of lifting-piece riding on count wheel. C. Hammer. D. Suspension.

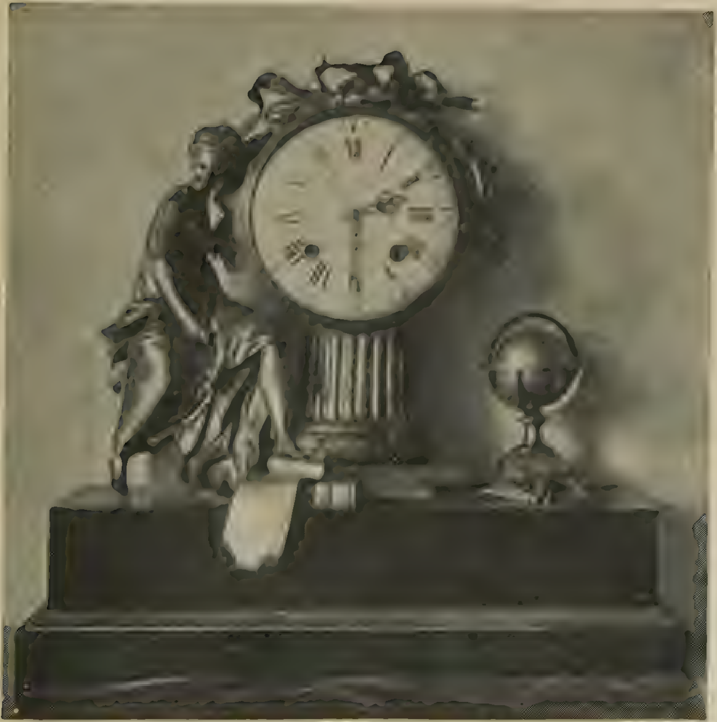
Remove the dial work by unscrewing the various bridges or cocks, but do not disturb those which carry pivots of the train. These need only be removed for actual repairs. Then let down both mainsprings. This is most important ; if inadvertently you unpin the plates with the springs wound up there will be something like an explosion, with considerable damage to the clock and possibly a badly cut finger. Put the key firmly on the winding-square, holding it tightly ; turn it a trifle until the ratchet lifts the click ;

then with your left thumb pressing on the tail of the click to keep it clear, allow the spring to run backward half a turn. Let the click drop into its place while you take a fresh grip and repeat the process. A watch maker will let the key revolve in his hand until the spring is down—a matter of a second or two; but it will be safer to let it down turn by turn. Do this with both springs, and make sure, by trying the barrels, that all the power is off.

Remove lifting pieces, hammer, count wheel (if present), and pallets; then unpin the back plate and lift it off slowly. Support the movement by resting it on the edges of an open box, so that the projecting arbor of the centre wheel is clear of the table or bench. If you feel any uncertainty, keep the going barrel and train separate from the striking barrel and train; some of the wheels are very much alike and this will make it easier to put the clock together. It may help you to note that broadly speaking the wheels decrease in size and weight as the train progresses—the larger ones are nearer to the barrel.

Cleaning a movement such as this is generally only a matter of brushing wheels and plates with chalk, pegging out holes and pinions, and polishing. Being so well protected by their cases, French clocks may go for years and accumulate very little dirt; but on close inspection there will be found fine "fluff" about the pivots and wheels, and what oil is left will be sticky. Polish well, and let the dry brush come last in order to remove all dust. In handling the plates after cleaning, hold them in a piece of tissue paper. Use petrol if the clock is very dirty.

In putting the movement together, rest the front plate on box as before; place the centre wheel in position, then the two barrels, winding squares downward, having first oiled the barrel arbors. (When the clock is going, the barrels revolve on their arbors; the arbors only revolve when the clock is being wound up.) Place the other wheels in position, the locking-piece, and hammer lifting-piece—which has a thin spring acting on a pin. No particular order need be followed. Then hold the movement in your left hand, and with the tweezers coax the pivots into their proper holes, the larger ones first. You will find that the top plate tilts most annoyingly, and that pivots will pop in and out as if possessed; but persevere, and, as soon as you can, press the plate gently down far enough to expose a pillar hole and clip in one of the pins—this will steady



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Decorative French clock, period Louis XV, by Masson of Paris. The case is of chased ormolu, on a plinth of black marble and bronze. (Victoria and Albert Museum, London, S.W.7.)

the plate and help considerably. It's a tricky business, the first time, and may make a severe call upon your patience; also, it is as well to be alone while doing this.

Resetting the Striking.—Rack movement.

Having pinned up the movement lightly, the first thing is to set the striking train in its correct relations, wheel with wheel. Put on the rack, its detent, and the gathering pallet, and drive the train by pushing the barrel teeth; the rack being gathered up, all but one tooth. When the hammer tail drops off the pin, the striking train must have the shortest possible run, so that the whole train stops neatly a fraction after the hammer has delivered its stroke. The reason for this adjustment is that on the next starting of the striking train the wheels shall have an appreciable run to get up speed before the strain of lifting the hammer begins. If the train came to rest with the hammer half lifted, not only would there be a possibility of a wrong hour, or a stroke at the "warning," but when the spring was nearly run down and the driving power therefore lessened, the resistance of the hammer might not be overcome and the clock would fail to strike.

To get this relationship between pin wheel and gathering-pallet wheel, take off the rack, detent, and gathering pallet; then disengage the wheel by slightly raising the top plate, and move the wheel a tooth or two onward in the pinion. Probably some of the other wheels will drop out; but keep calm. It is not an easy job for the amateur, and it is quite possible that only after several trials (in both senses of the word) will this crisis be overcome. Remember that if the striking is left improperly adjusted there will be trouble later on, without a doubt.

Next, see that the warning-pin on the wheel gearing into the fly pinion is half a turn away from its lifting-piece when the train comes to rest. To adjust this, raise the top plate again very gently until the pivot is free and the pinion of the warning wheel can be disengaged for a moment. The fly pivot will come out of its hole every time you do this, but that doesn't matter ; be careful, however, not to raise the plate so much that the pivots of the larger wheels, which you have previously adjusted, slip out, or you may have the hammer-lift wrong again.

In many clocks the principal back pivots are carried by separate bridges or cocks ; this simplifies matters, as by removing the requisite bridge you can disengage a pinion without displacing other pivots. If you find a dot on the rim of the pin-wheel, and a mark on the pallet-wheel pinion, put these in conjunction ; they are to assist in the correct setting of the striking.

All the pivots of these wheels are delicate, and any attempt at forcing is dangerous. As I have said before, a broken pivot means that you go, hat in hand, to the watchmaker, who is invariably tickled to death when a clock is brought to him wheel by wheel, as it were, instead of entire, with a fairy story about " an accident." Should you bend a pivot, it may be straightened, as a rule, with a fine pair of pliers, first heating it slightly in a spirit-flame ; this should be done in one operation—a *second* bend, to get it perfectly straight, is quite likely to snap it. Therefore consider the angle well before rectifying it.

When the striking is right, pin the plates together firmly, remove the rack and any other dial work, and oil the pivots, the pins that lift the hammer, and the point of contact of the hammer spring. Do not let superfluous oil run down the plate ; for the finer pivots, a pin with flattened and filed point makes a good oiler—nip off the head and push it into a small piece of pegwood or any other suitable holder. Then put on all the dial work, making sure that everything works freely, and with minute hand in position try the striking round, winding the mainspring up a couple of turns. See that the warning piece falls when the minute hand is exactly upright; if not, disengage the motion wheel and move it a tooth or two forward or backward as required. Give a slight touch of oil to the steel pins that carry the rack and lifting-pieces.

The rack, its detent, and the warning-piece must be perfectly free on their fixed pillars; if they have the slightest inclination to "stick" the striking may go wrong after a few days or weeks, and the clock may stop. On examination you may find a spot of rust, or a roughness, to cause this. Conversely, none of these parts must have much "play" and occasionally the addition of a thin collet (*i.e.* a washer) between the rack and the pin that keeps it in position will be an improvement. See that the rack-teeth are smooth, that the gathering pallet picks them up neatly, and that the rubbing surface of the detent is bright. The whole striking gear should run sweetly and stop with scarcely perceptible recoil. If the train shows much recoil before it settles down at the end of the run, probably the fly is too tight on its spindle: this can be eased by bending its spring slightly outwards with the point of a fine punch or an old pair of

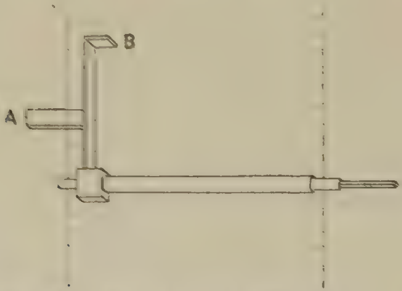

Fig. 36.—Count-wheel lifting-piece of French striking clock.

Projection A passes through slot in back plate and rides on rim of count wheel. Square edge B stops revolution of train when A falls into a notch of the count wheel. Dotted lines show position of plates.

tweezers. The two pins in the motion wheel which lift the warning-piece at hours and half-hours must be burnished.

When you feel that you have everything correct, put in the pallets, and touch their working faces with watch oil. (All French clocks should be oiled with watch oil, except the large bearings of the barrel arbors.)

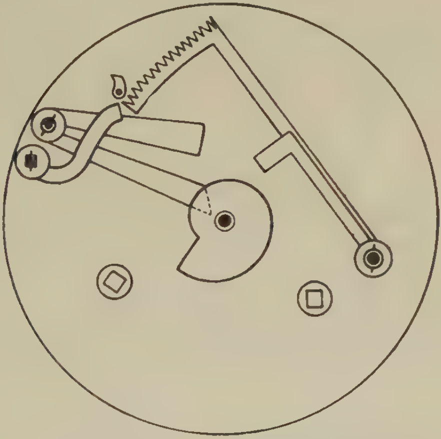

**Fig. 37.—Front plate striking work of French clock (rack held-up).**

Resetting the Striking.—Count-wheel movement. The train is stopped by a pin in the wheel next to the hammer or pin wheel coming against the edge of the inner part of the lifting-piece controlled by the count wheel. The procedure and the principle are precisely the same, the golden rule being that the train must never be locked with the hammer on the rise. Never attempt to bend the count-wheel lifting-piece (fig. 36), or to alter the spaces in the count wheel by filing, however tempting it may be. The striking can always be put right, provided nothing is bent or broken by a fall or accident, without any bending of lifting-pieces in any well-made clock.

*Faults in the Striking Action.*—All pins and surfaces that stop a running train suddenly—*i.e.* the stop-pin and its lifting-piece, the warning-pin and its lifting-piece—should act squarely. Occasionally a count-wheel clock will "jump" its stop-pin and go on with the next hour; if this happens, examination will generally show that the stop-pin is bent or loose, or the square edge against which it beds is worn. Either of these faults can be corrected. The insertion of a new steel pin (a needle, softened, filed, burnished, fitted, and hardened, makes an excellent pin) is an easy matter; it should fit very tightly. If the edge of the lifting-piece is cut or battered, file it flat and smooth and burnish it. This is easy to write; but it is not so easy, as all model engineers know, to file by hand even a small surface perfectly flat; the tendency is towards convexity. And although the acting surfaces in a clock are very small, there is every reason that they should be accurately shaped. A troublesome striking can sometimes be cured by removing the count wheel and replacing it on its square after turning it round, a quarter or a half-turn.

*Suspension and Regulation.*—The pendulum, in most French clocks, has the usual double hook at the top of its rod, which slips over the pin in the suspension spring. Instead of raising or lowering the bob, the finer regulation is accomplished by the Brocot device, which consists of movable brass jaws clipping the suspension spring and making the part of the spring above the jaws inactive. The movement of these jaws is controlled by the long spindle ending in a square which passes through the dial just above the figure XII, and can be turned by an ordinary watchkey, or, if too large for this, by a pair of pliers. The rear end of this spindle carries a small wheel which gears at right angles into a similar wheel having a threaded extension carrying the clamp; thus by turning the regulating spindle horizontally a few revolutions the clamp moves vertically. A little examination will show that a fine degree of regulation can be attained by this attachment.

A damaged suspension spring should never be passed; the clock may go, but the pendulum will " roll." and good time-keeping cannot be expected. New springs can be bought ready-made, requiring only a little fitting.

A few French timepieces have a silk suspension—the pendulum being simply hooked into a loop of silk. If this is frayed or broken, it can be replaced from the feminine work-basket when no one is looking.

## CARRIAGE CLOCKS

Most of these clocks are timepieces—that is, without striking trains—and more nearly approach watchwork than any other class of clock. The escapement in fact *is* watchwork, having balance wheel, hairspring, and either a lever or cylinder action. As with the French striking clock, they should not be dealt with until some experience has been gained with larger work.

*Cylinder Movement.*—In this type of movement there are no separate pallets. The scape wheel, with teeth of a peculiar shape, acts on the edges of the hollow " cylinder " which forms part of the balance axle, throwing it alternately to right and left—the edges of the cylinder being equivalent to the pallet faces. The point of each tooth, as it comes round, is held up momentarily by the outer surface of the cut cylinder; the cylinder, revolving, receives an impulse as the slope of the tooth passes the slot, and the tooth comes to rest for a fraction of a second on the inner surface of the cylinder, to give a second impulse as it passes clear. A few minutes' scrutiny of the escapement, with the eyeglass, will make the action clear (fig. 38).

The movement slides out from the lower part of the case after the false bottom (a brass plate held by a screw) and, generally, the four feet, have been unscrewed. The escapement can be taken off bodily by its bridge and set aside. Cleaning is chiefly a matter of brushing and polishing; this should be carefully done, as a great part of the movement is visible through the glass sides and back, and, as with all highly finished clocks, wheels and plates after cleaning should be handled with tissue-paper or tweezers, to avoid finger-marks. There is no need to take out the mainspring unless it is sticky, but the barrel-cover should be prized off and a couple of drops of oil allowed to flow over the coils. Wipe the barrel arbor and clean the holes thoroughly.

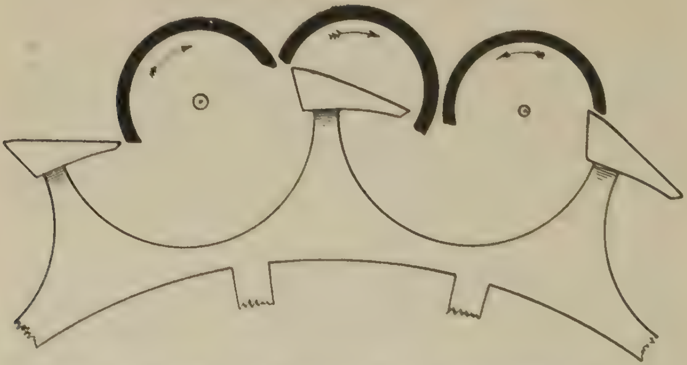

Fig. 38.—Action of cylinder and scape-wheel teeth.

Having put the simple train together and tried it for free running, take the escapement to pieces. Unlike the old verge clocks and watches, where the hairspring is pinned through a stud on the plate, in modern watch escapements it is pinned through a stud on the balance-cock; cock, balance wheel, and hairspring therefore come away together. As you lift the cock off with the tweezers, turn it slightly in either direction to free the cylinder from the scape-wheel teeth. Never pull it straight up more than an inch or so—you may distort the hairspring, and to get a misshapen hairspring nicely flat again is enough to try an angel's patience and self-restraint. Set the balance and cock aside, upside-down to avoid damage to the pivots, and then take off the scape-wheel cock and lift out the wheel. It is of steel, and very delicate, and only the softest brush can be used on it ; even then you must be careful not to brush it away or to catch it in the bristles. You can hardly feel it in your fingers, and it must be held very gently indeed. The best way is just to dab it lightly with the brush with a little sideways motion, and not to risk straightforward up-and-down brushing, such as you give to more robust wheels. Peg out the pinion very cautiously with the pointed end of a match or pegwood, using the eyeglass, and removing all traces of fluffiness. It is astonishing how microscopic hairs and particles will cling to these scape wheels.

The holes of this wheel will certainly be jewelled—or at least the top hole. Peg them out carefully, without pushing much, so as not to displace or crack the stone, and, before replacing the wheel, oil the bottom hole with watch oil.

Do not unpin the outer coil of the hairspring ; push the stud out bodily, with a blunt point, from the top of the balance-cock ; cock and balance will then separate, the hair-spring coming away with the balance, the stud remaining on the spring. Dab the balance and spring with the softest brush with extreme gentleness, and just touch the cylinder with the pegwood-point to remove any dust. The cock holes, having an endstone as well as a jewel, should be pegged with a blunt pegwood—a sharp point will probably bend or break off—and be oiled before the balance is replaced. To do this, lay the cock on its back and taking the hairspring-stud in the tweezers, insert it in its hole and push it well home right up to the shoulder. Then hold up the cock and balance and twist the stud a little with the tweezers until the outer coil of the spring is free between the two regulator pins. Sometimes one of these pins has a movable catch which encloses the outer coil; this is easily swivelled aside.

Replacing the balance requires particular care if the amateur is to avoid a broken pivot. Take the cock in the tweezers, hold it just above its correct position, and "wiggle" the cylinder down past the teeth of the scape wheel until it seems to settle; the balance wheel drops a trifle as the bottom pivot enters its hole. Then put the cock in place and screw it up until the screw *just* begins to grip it. Screw it no further until you have got the top pivot of the balance in and a swing sets the wheel vibrating freely; then you can screw up, but cautiously, as, if the cock has not correctly settled into place, the pivot may slip out again. Again examine the position of the outer coil of the spring; if it is not free between the pins regulation will be faulty. It should be perfectly free at "Slow," and it may touch the inner pin at "Fast."

Put the whole escapement in place and screw it home; then a half turn of the key should set the clock going.

*Lever Movement.*—The lever escapement of a carriage clock is very similar to that of the cheap nickel alarm clock dealt with in Chapter 9, but is finer and much more highly finished. You can distinguish between the cylinder escapement and the lever escapement by sound as well as by sight, the sharp "tick-tick-tick" of the former being quite different from the double "click-click-click" of the lever.

The pallets, carrying the lever, form a separate piece with an arbor (the pallet staff) and pivots, as shown in fig. 29, though not necessarily of the same shape. They are very fine, and the whole of these escapements need the greatest care, watch tools—tweezers, small screwdrivers, and eyeglass—being absolutely essential.

## CARRIAGE STRIKING CLOCKS

When you examine a high-class carriage striking clock you will notice that there are variations of the usual arrangement of the mechanism ; but, following our principle of close scrutiny before taking any clock to pieces, no exceptional difficulty should be found. However, these beautifully finished movements should not be attempted until some practice has been gained with less delicate work.

The going train needs no special description ; going trains are much alike. The escapement is sure to be of the lever type, and detachable ; it should be set aside until the clock is otherwise finished.

There will most likely be a repeating attachment to the striking side ; therefore no warning provision is found—for the reason that the train is entirely held up during the period before the warning lifting-piece drops, and thus the hour would not strike in that period even when the repeating-stud was pressed. Also, the customary slowly moving snail will not do for a repeating clock if you desire that the *last* hour should be repeated—because, after the half-hour, the snail on the hour wheel will have moved on towards the position for the *next* hour, and the rack will drop too far ; therefore the clock would be very likely to give one stroke in excess.

This little problem is overcome by mounting the snail on a separate bearing, and attaching to it a " star " wheel—that is, a wheel with twelve large ray-like teeth (though it is not really a wheel at all). Upon this star or flirt presses a kind of click, specially shaped and sprung, so that as the usual pin in the motion work slowly engages with the star and moves it round, there comes a moment when the click takes charge and completes the one-tooth-space revolution of the star with a jerk, suddenly. This " flip " takes place just before the striking train is set free at the hour.

For the single stroke at the half-hour an extra lifting-piece is mounted which allows the rack to drop one tooth.

The arrangement of the lifting-pieces is rather different from that in the ordinary French striking rack mechanism, but presents no special difficulty. An extraneous piece, operated by a button mounted on an arm, passing through the top of the case, effects the repeating action, and is so designed as to stop the revolution of the fly until it is released. It also causes the rack to fall quite freely whatever stage the snail or the general dial work may be in.

In putting the striking work together you will probably notice, in many high-class clocks, punch-marks on the minute and motion wheels. If these wheels are put on so that the dots are as close together as possible, the position of the lifting-pins should be correct.

The idea underlying the construction of carriage or travelling clocks is that they shall not only go in any position, but that the complete mechanism shall remain undisturbed and act perfectly when the clock is packed and perhaps subject to the jerks and rough handling of a journey. For this reason many of the parts liable to be displaced are provided with springs which are absent in other clocks. It is essential, therefore, to see that every lifting-piece swings on its mounting with absolute freedom, and that all clearances between moving parts are correct, and so limited that no interference can be caused when the clock is lying on its back, or face downward. Pins and collets that restrain endshake must be smooth and a good fit, for the dropping out of a single pin may prevent the striking train from coming into action, or may, on the other hand, allow it to run right down. Every stud carrying a lifting-piece should be polished or burnished to eliminate the smallest trace of roughness ; the invisibly burred edge of a pin hole, for instance, may cause trouble in a delicately made set of dial work.

## CYLINDER ALARM

For the construction and cleaning of this type of clock see "Cylinder Movement"; the escapement is precisely similar. The clock itself is usually in a circular brass case, and the movement slides out easily when the two feet and a screw at the top are removed.

The alarm bell, instead of being outside the case as with cheap nickel clocks, is on a short arm fixed to the movement, and gives a pleasantly musical note.

When putting the movement together, do not forget to include the small flat steel spring which tightens the spindle on one end of which the alarm hand is fixed; this spring presses against the inside of the back plate.

To adjust the alarm, put the hands on lightly, wind the alarm mainspring up half a turn, and by means of the key turn the hands round until the alarm rings. Then put on the alarm hand lightly at that hour, as nearly as possible. Set the alarm, and try it a few times, altering the minute hand as necessary until the alarm goes off within a few minutes either way of the determined time. Fix the hands on firmly, and all should be well. If the flat brass stop-piece which engages the tail of the hammer is not correctly adjusted it may fail to rise clear when the alarm wheel is due to set it free; this fault can be corrected in a momen by bending the brass strip.

The *tone* of the alarm can be considerably deepened and its slumber-spoiling effect much increased by standing the clock on any hollow object (such as an empty cigar-box) which acts as a sounding-board.

## CUCKOO AND TRUMPETER CLOCKS

The wires, bellows, and lifting-pieces of these "fancy" clocks give the movement a rather complicated appearance, and do, as a matter of fact, introduce a few extra worries if anything happens to go wrong. But if you have arrived at the stage of fearless attack caused by the successful cleaning and repair of an ordinary troublesome American striking movement there is no reason to hesitate at tackling a cuckoo clock.

In some respects these clocks are simpler to deal with than the average, because they have wooden "plates," easily removed by taking out the pins that are pushed into the wood at the top, each train as a rule coming out separately.

Instead of the single hammer, we have two lifting-pieces attached by long wires to the pair of bellows; the bellows, at the top of the clock, sound the two notes of the "cuckoo," and a wire fixed on one of the bellows works the simple wire joints of the little wooden bird, which flicks its tail and bows in the quaint manner that thrilled our childhood's days. An ordinary hammer strikes the coiled-wire gong. Each bellows delivers its breath into a miniature organ-pipe fixed to the case.

The usual precautions are to be taken when putting the movement together. No lifting-pieces must be actually on the lift when the striking train comes to rest; they should be quite clear of their various pins; and the warning-pin acts in the usual way, requiring about half a revolution of its wheel to warn properly. The form of striking is invariably the count wheel.

Trumpeter clocks have three bellows and of course a third lever; otherwise they are similar to cuckoo clocks.

No special differences are indicated for the cleaning of these clocks, but it occasionally happens that one of the bellows gets torn or spoiled. The best way to repair this is to cut a pattern in paper of the shape and size required, then, having by trial obtained a correct fit, cut the same shape out of the wrist or arm of an old kid glove, and glue it into position on the upper and lower half of the bellows frame. This will be soft and flexible and sufficiently air-tight ; but the clock must not be used for several hours after this repair, so that the glue may dry well.

A point to bear in mind is that the right lifting-piece must connect with the right bellows—otherwise the cuckoo will " 'oo before it cucks."

As a rule the pendulum has no spring, but is suspended by a loop of wire ; the point of swing should be oiled.

## MAINSPRING REPAIRS AND HINTS

The method of putting in a new mainspring varies according to the type of clock, and is described under separate headings. When obtaining the new spring, take the broken one as a guide to the material dealer, who will match it as closely as possible ; if the clock is a French or Swiss going barrel it is just as well to take the barrel too. The reason for this is that the dealer or his shop-man will then select a spring of about the correct " fullness." A spring, when down—lying inert in the barrel—should not fill much more than half of the barrel space. In putting in a watch mainspring it is often necessary to break off the outer coil in order to lessen the bulk of the spring in the barrel. You can see (with thinking cap adjusted) that a mainspring which *filled* the barrel would be almost wound up, although it was run down. This sounds bad, but is quite correct. It would be run down as far as the space of the barrel would allow, yet so fully wound that very few turns of the key would suffice to wind it up completely. Get in your mind's eye a picture of what happens when you have wound up the clock : the spring is then coiled tightly round the barrel arbor in the centre, and entirely clear of the barrel walls save for its end, which is caught on the barrel hooking and trying with all its might to pull the barrel round. Briefly, it is driving the train.

It is a pretty strong drive, and when a fully wound mainspring snaps, the jar is so severe that a tooth or two of the train may be bent, or even broken. The necessity for a sound and firm barrel hooking, correctly shaped, is obvious. A worn hooking should be either touched up with a small sharp file or replaced, the new one, if needed, being made from steel rod and screwed or riveted into the hole in the barrel. This, however, will not often be found necessary.

A mainspring broken half-way or near the centre should be discarded ; repair is possible, but unsatisfactory, and not worth while. If, however, the outer coil only has snapped repair is easy. Soften the end of the spring by holding it in the flame of a spirit-lamp (but not to red heat), and punch a hole in it, either properly on a stake in the vice, or improperly by punching an indentation, holding the end of the spring on a piece of hard wood, and filing off the bump. Then file or broach the hole until it fits over the barrel hooking, remove all burrs, bevel it slightly at the inner side of the hole so that it goes neatly into the cut or slant of the hook, and reshape the outer edge of the spring, rounding off the corners and taking off any wide margin, which would tend to give it a purchase on the barrel, and might force it off the hooking when the spring was wound up. There is no need to harden the end of the spring ; but it is important that it should not have been softened too much in the flame.

To test your work, also to make sure of a new spring, replace the arbor and barrel cover, grip the square of the arbor firmly in the vice, and wind up the spring by turning the barrel till you feel the pull of the completely wound spring ; then let the barrel revolve, with your hand as a brake, till the spring is down. This wants caution when done for the first time, but is perfectly easy as long as you are careful of two things—to have the arbor very firmly gripped, and to let the barrel revolve slowly. If you don't, there will be a run for sticking-plaster. Both hands are needed, and a little gumption.

After that oil the spring in the usual way ; snap the cover on tightly, and make sure that it is right in and flush with edge of barrel ; and oil the two holes.

If the spring is sticky you can feel it thumping as you wind up the clock. The reason for this is that coils are adhering because the old oil has become gummy, therefore they give quite perceptible jerks as the clock is wound. The spring then should be taken out and cleaned in petrol. To do this, hold the barrel in a soft leather or duster in the palm of the left hand, and with pliers pull out the centre of the spring slowly, easing it by giving it a slight turn in the direction of winding. At a certain moment the spring will begin to fly out ; this can be restrained by the fingers of the left hand, and you can then drop the pliers and guide the coils out.

After cleaning and wiping spring and barrel, wind the spring in again from the outer end. (There is a tool called a mainspring-winder, which winds up the spring from the inner hooking until you can pop the barrel over it ; but it is not difficult to wind in an ordinary spring by hand.) Place the barrel, on a soft leather, on the bench ; insert the end of the outer coil and see that the barrel hook is properly through the hole in the spring. Then with both hands, pressing downwards strongly, coil the spring back turn by turn into the barrel. It becomes more easy as you proceed, until the last few coils at the centre slip in almost of their own accord. Bang the barrel smartly and flatly on the bench to settle the coils ; if any still show their edges above the others, press them down firmly with the rounded handle of the nippers or any smooth, hard tool—otherwise the barrel cover will not go on. Then oil the spring, put in the arbor, and make sure that the centre coil fits snugly round it and that the hook enters the hole in the spring ; nothing is more annoying than to get a clock together, nicely cleaned, and find the mainspring " slipping," as it is termed —that is, the winding arbor just catching up the spring and letting it go after a turn or two. The cause of this is the hook on the barrel arbor just catching its tip on the *edge* of the hole in the spring, and of course dropping it when the strain of winding comes ; there is no remedy but taking the clock to pieces again. So make perfectly certain that the hook of the barrel arbor is *through* the hole, and not merely catching the edge of it. A mainspring will also " slip," after a few turns of the key, if the outer or barrel hooking is faulty.

## REPAIRS TO WHEELS

Practically the only repair to a wheel that will come the way of the amateur is the replacement of a broken tooth. A bent tooth can sometimes be straightened, if it is not too bad, by using the root of an adjoining tooth as the fulcrum and levering it back into position with a thin (but not flexible) piece of smooth steel ; the blade of a knife will often serve. But a badly bent tooth, if straightened in this way, is liable to be a weak tooth, with an incipient flaw in the brass.

There are two methods of replacing a broken tooth. One is to drill a hole in the rim of the wheel, tap it, and screw in a piece of brass wire ; nip it off, and shape it as well as possible ; this is not the best way, though it may be the most convenient in certain emergencies.

A far better job can be made by cutting out a piece from the rim of the wheel as shown in the diagram (fig. 39). Cut diagonally from the root of each adjoining tooth, marking your outline first with a sharp steel point, and being very careful not to go too close to the inner part of the rim. Use a fine saw, and grip the wheel in the vice, protecting it by a piece of card or cloth. You will then have an interesting job, if you are at all handy with small tools, to file up a scrap of brass, the same thickness as the wheel, or a shade thicker, to fit this opening so snugly that a tap with a light hammer will drive it home tightly ; on this piece of brass you will have roughly formed a projection for the future tooth ; Before fitting it in its gap, tin the edges with soft solder ; drive it home, and warm it till the solder runs freely. This is one of the repairs where secure riveting is almost impossible, and soldering is not " the bad workman's best friend." Clean it off, and with your small watch-files shape the tooth, taking plenty of time about it. When finished off, filed flush, emery-papered, and polished, you should hardly be able to see that a new tooth has been put in, and it will be just as strong and serviceable as the others.

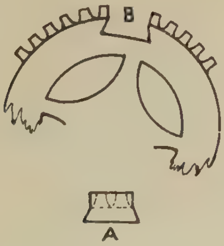

**Fig. 39.—Repairing a wheel.**
A. Piece of brass to fit in space B.

Two or three teeth that have stripped off—as occasionally happens through the breaking of a strong spring, or by some accident—can be replaced in exactly the same way ; but greater care will be necessary in shaping the new teeth and spacing them correctly. Always, after a repair of this description, put the wheel and its neighbour into which it gears in position between the plates ; pin the plates together properly, and make sure that the two run freely. If there is the slightest bump or catch or hesitation where the fresh tooth engages its pinion, the clock will stop; you will probably find it necessary to reduce the thickness of the tooth by the merest trifle; or possibly the new tooth is a shade too high. If you have a small lathe, the best plan is to slip the wheel between the centres and top it.

A broken wheel ought to be replaced by a new one; but I have seen quite a good emergency repair done by drilling a couple of holes each side of the break and riveting a plate across. This needs no description; the only point to be looked after is that the repair must clear the neighbour in wheels; in some clocks the clearance between certain wheels is very small.

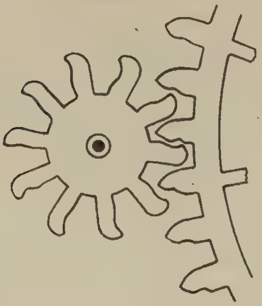

**Fig. 40.—Teeth of wheels badly worn.**

## SETTING A CLOCK IN BEAT

All clocks—and watches—require to be " in beat " before they give their best performance. It is quite probable that there are some thousands of house clocks stopped at the present moment simply because they are out of beat, and thousands more going badly for the same reason.

A clock that is even slightly out of beat can be detected instantly by the sensitive ear, and, once you have learned to recognise the irregularity, it becomes positively painful to sit and listen to it. Many a time I have laid hands on a clock in the house of a friend and set it in beat, simply to relieve the distress of hearing the poor thing ticking laboriously and uncomfortably and lamely ; and I always have a feeling that the clock is grateful for the little attention—whether its owner is or not. Model engineering friends will understand without further explanation ; it is just the difference between a sweetly running engine and one, let us suppose, that " knocks," or leaks at the stuffing-boxes. And, as I always emphasise, a clock should be regarded as a piece of machinery —as much so as an engine or a motor, and worthy of the most careful adjustment.

Many people, aware that something is wrong, will equalise the beat by propping up the case of the clock, if it is standing on a mantelpiece or shelf, or by shifting it sideways if it hangs on a wall. This is perhaps better than doing nothing ; but it is of course not shipshape.

A clock out of beat means that the pallets, when at rest, are not correctly placed with regard to the teeth of the scape wheel. Stop the pendulum, and draw it slowly to the right or left until you hear the " tick "—the drop of the tooth on the pallet face. Then let it go, without giving it any push. At the end of the swing another tooth should drop, and the pendulum should carry on. If the second " tick " does not occur, the pendulum will swing idly and gradually come to rest ; nevertheless, if set off by hand with a good swing, it may still go on unless the beat is very much " out."

To set this fault right, the wire connecting crutch and pallets must be slightly bent between thumb and finger ; one or two trials will show you the effect, and will not injure the clock. The thing to be careful about is that you do not bend the crutch itself out of its horizontal position, or bend the wire so that the pendulum rod binds in the crutch. With a French clock striking on a bell you may have first to unscrew the nut and remove the bell; if it has the customary coiled-wire gong, you can slip your fingers in without disturbing it. Take care not to buckle the delicate suspension spring, and the strain of bending must be taken by your finger and thumb, not by the fine pallet pivots.

Most French clocks with visible escapements can be set in beat simply by giving the pendulum a good swing out when starting them. The pallets being a moderately tight fit on their arbor, and not fixed as in the usual way, give to the movement of the heavy pendulum and settle down in a few moments to a normal correct action. Vienna regulator clocks usually have a screw attachment on the crutch by which the pin which moves in the slot of the pendulum can easily be adjusted to the right position.

Other clocks, such as long-case Americans with weights carried on cords passing over pulleys in the top of the case, and varieties in what we may term " mantelpiece " clocks, need not be taken in detail. They present no special difficulties, once the reader masters the principles and has gained familiarity with clock work by practice. And that is the only way to success, with a little patience at moments when " everything seems to go wrong."

## ELECTRIC CLOCKS

The electric clocks that are now on sale in a variety of designs for plugging into the house supply points, depend for their accuracy entirely upon the frequency of the current (number of alternations per second) sent out from the power stations, and not, as with the ordinary clock, upon time-keeping mechanism in the movement itself. One of the aims of the Central Electricity Board, formed in 1926, was to standardise throughout the country the frequency of generation, and this is now 50 cycles per second. As long as that frequency is maintained, an electric clock of this type will keep time ; in fact it cannot do otherwise, for it has a tiny electric motor running at a definite speed and actuating the dial-work through reduction gear.

Amateurs should not attempt any adjustment or repair of these mains-driven clocks. They are designed with great care and highly finished. Their original lubrication will last for years, and they are despatched by the makers—who are electrical and horological firms with well-known names —in a condition to give good service for a very long period.

There is, however, a large family of electric clocks which can be classed more correctly as electro-magnetic. Given a very elementary knowledge of electrical action, and some acquaintance with clock work in general, the amateur will be able to grasp the principle of any examples he may meet. Some are very simple ; indeed it is not at all difficult to "make" a good timekeeper of this type by adapting the works of an ordinary nickel alarm and adding an electro-magnet, contact device, pendulum, and battery. In this and other types of clock in which the motion of the pendulum is maintained by electro-magnetic impulses, the pendulum drives, instead of being driven ; it is, in fact, the motor, and the only work the very few wheels have to do is to move the hands.

Some of these clocks operate by the direct pull of an electro-magnet upon an armature fixed to the bottom of the pendulum. As the swings of the pendulum die down, a little trailing "trigger" catches in a notch in a small steel block and actuates a contact-arm ; the magnet is energized, and gives a pull just as the armature passes over it. The arc of the pendulum is thus increased, and the trigger again trails or idles across the steel block until once more the arc of swing is lessened and another momentary contact is made.

Other electrically driven or controlled clocks operate by means of a weighted arm which is released at the correct instant at definite half-minute intervals and gives an impulse to the pendulum by gliding down a suitably shaped piece attached to the pendulum rod. As this gravity arm completes its fall it makes an electrical contact and is raised and re-set by the action of an electro-magnet.

These and other types of clock in which electricity is the driving or controlling power are fully described and illustrated, with instructions for making, in a book entitled *Electric Clocks and Chimes*.*

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## TERMS USED IN CLOCK AND WATCHWORK

*Arbor*—Axle or spindle.

*Balance staff*—The arbor of the balance wheel. Often called merely "the staff."

*Banking pins*—The two fixed pins which in a lever movement limit the action of the lever. Any pins which limit action protectively in this way.

*Barrel*—The circular case containing the mainspring.

*Cannon pinion*—The pinion or wheel, sometimes having a tubular extension, which fits on the centre wheel arbor and revolves with it, either friction-tight or by the pressure of a spring. In some clocks, with a small cannon pinion driven on very tightly, the centre wheel arbor is friction-tight in the wheel, and the cannon pinion does not move upon the arbor when the hands are turned.

*Centre wheel*—The wheel, usually at the centre of the movement, which revolves once in an hour and as a rule carries the minute hand on an extension of its arbor.

*Click*—A pawl.

*Clickwork* or *Ratchet-work*—The pawl and ratchet of the winding work, also of the barrel arbor in some types of clock.

*Cock*—A light bridge carrying a pivot and generally fixed to the plate by one screw and steady-pins. Chiefly used in watchwork, as balance-cock, scape-cock, etc.

*Collet*—A metal washer. The collet in front of the minute hand of a clock, kept in place by a pin, is usually dished.

*Count wheel* or *Locking-plate*—The circular locking-plate, notched at graduated intervals from 1 to 12, which in a count-wheel clock governs the number of hours struck.

*Crown wheel*—In a verge watch, and some carriage clocks, the wheel next to the scape wheel, having contrate teeth (teeth parallel with its axis). The scape wheel thus driven is set at right angles to the crown wheel instead of in the same plane.

*Crutch*—The fork, attached to the pallet arbor, in which the pendulum rod works, and by which the impulse given by scape wheel to pallets is transferred to the pendulum.

*Depth*—The degree to which a wheel and its pinion engage.

*Dial work*—The motion work, lifting-pieces, etc., outside the front plate, visible when the dial is removed.

*Endshake*—The play or " shake " of a wheel between the plates when they are tightly pinned together.

*Endstone*—The end stone of a jewel hole ; usually fitted only to the balance pivot holes of a watch.

*Escapement*—The scape wheel and pallets, by the action of which the pendulum or balance wheel is kept in motion at a certain rate, and which control the time-keeping qualities of a clock or watch.

*Fly*—A revolving vane or fan driven from the last wheel of the striking train which by its resistance to the air checks the tendency of the train to run too fast.

*Fusee*—The grooved conical main wheel of an English dial clock, and of some English lever watches, by which the power of the mainspring is equalised as it runs down. Driven by a gut line or chain from the barrel.

*Gathering pallet*—The little single-toothed revolving piece in a rack-striking train, outside the front plate, which picks up the rack one tooth at a time as the clock strikes.

*Going barrel*—A barrel and toothed wheel in one, gearing directly into the train without the intervention of a chain or line.

*Going train*—The time-measuring group of wheels, as distinct from the striking train.

*Hour wheel*—The largest wheel of the motion work, revolving once in twelve hours and carrying the hour hand.

*Lifting-pieces*—Levers which are lifted by pins on the motion wheels or other parts of a striking clock, and which set free, arrest, or control the striking train.

*Motion work*—The wheels outside the front plate, immediately beneath the dial, by which the once-an-hour revolution of the centre wheel causes the once-in-twelve-hours revolution of the hour wheel.

*Movement*—The mechanism of a clock or watch without its case.

*Overbanked*—A lever watch or clock is said to have " over-banked " when the impulse-pin on the balance wheel is out of position and outside the fork of the lever ; or in a horizontal (cylinder) movement, when the cylinder has revolved too far and is held by a tooth of the scape wheel. Correctly placed banking pins should prevent this.

*Pallets*—Strictly, the faces of the rocking lever acted upon by the teeth of the scape wheel. Commonly applied to the whole piece, consisting of pallets, pivoted pallet arbor or staff, connecting arm, and crutch ; or, in a lever watch, the pallets, pallet staff, and lever.

*Pallet staff*—The arbor of the pallets.

*Rack*—The toothed segment in a rack-striking clock which drops a determined distance, governed by the position of the snail, at each hour.

*Rising-board* or *Seat-board*—The base-board of an eight-day or thirty-hour grandfather clock, to which the movement is bolted or screwed.

*Ruby pins*—The half-round jewel pallet pins of the visible escapement of certain French clocks.

*Scape* or *Escape wheel*—The last wheel of the going train, which transmits to the pallets the power of the spring or weight.

*Snail*—The spiral disc of brass, generally attached to the hour wheel and revolving with it, stepped or curved from one to twelve, against which the rack-tail falls, governing the number of hours struck.

"*Stopper*"—A clock or watch which after being cleaned and repaired and re-examined refuses to go, or stops at irregular intervals. The black sheep of the horological world.

*Stopwork*—The device which prevents overwinding. Absent in many clocks and watches.

*Train*—The set of wheels that connect the barrel or fusee with the escapement.

*Warning*—The partial unlocking of the striking train just before the hour or half-hour.

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